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17 January 1980

# USSR Report

## RESOURCES

No. 913

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# USSR REPORT

## RESOURCES

## No. 913

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# THE HEAT SUPPLY FOR MOSCOW OVER THE PERIOD UP TO 1990

Moscow ENERGETIK in Russian No 9, Sep 79 p 39

[Article: "In the Scientific and Engineering Council of the USSR Ministry of Energy; the Heating Supply Plan for Moscow over the Period up to 1990"]

[Text] The heat supply plan for Moscow over the period up to 1990 has been worked up by the Mosenergoproyekt [Moscow Power Engineering Planning Administration] Institute.

Moscow occupies an area of 878.7 km$^2$ and is bounded by the Moscow Motor Vehicle Beltway. The population of the city at the start of 1976 was more than 7.7 million. The demand of the city for heat over the period 1965-1975 increased 1.68 times, which corresponds to an annual growth of 5.5 percent. The maximum hourly demand of the city for heat in 1975 for heating, ventillation, hot water supply and production process requirements amounted to 27,700 GCal/h.

At the start of 1976, the city was supplied with heat from the following heat sources:

--14 heat and electric power stations with an overall thermal power of 19,539 GCal/h;

--20 regional heating boiler facilities (RTS), with an overall thermal power of 40,550 GCa./h;

--1,070 industrial heating boiler facilities with an overall thermal power of 11,100 GCal/h;

--2,270 local heating boiler facilities with an overall thermal power of 5,850 GCa./h.

Centralized heat sources (TETs and RTS) covered 75.2 percent of the city's demand for heat, and the scope of heat and power supply reached 62.8 percent.

Some 2,483 km of heating lines have been run from TETs and RTS's, including 64 km of steam lines from TETs. The heating mains are predominantly run underground in impassable channels. The Moscow heating supply system is a closed, dual pipe system. At the majority of TETs, a central qualitative control schedule with respect to the overall heating load and hot water supply has been adopted as the control graph for heat distribution. The maximum design temperature of the mains water is 150° C.

The predominant configuration for the connection of heat consumers is the dependent type, primarily through elevators - 75 percent, while the remaining 25 percent of the consumers are connected in an independent configuration, and the fraction of such connections is increasing annually.

The specific consumption of conventional fuel for electrical power generation from the Moscow TETs of Mosenergo in 1977 was 226 g/KWH and was below the average consumption of all of the TETs of the USSR Ministry of Energy by 45 g/KWH or lower by 16 percent, and 129.5 g/KWH lower than the figure for condensation stations, or down by 35 percent. Correspondingly, the specific consumption of conventional fuel for thermal power generation was 166.2 kg/GCal and was 25-40 kg of conventional fuel lower than for small industrial and heating boiler facilities.

The maximum hourly demand of the city for heat, hot water and steam was determined to be the following figures (GCal/h):

| 1975 (reported) | 1980 | 1985 | 1990 |
|---|---|---|---|
| 28,105 | 34,505 | 40,825 | 48,260 |

As a result of considering the different variants for meeting the demand of the city for thermal power over the period up to 1990, the maximum development of TETs's using organic fuel was recommended. A provision is made for the construction of a new Severnaya TETs, the expansion of the branches TETs-9 (TETs-8), TETs-21, TETs-23, TETs-25 and TETs-26 (Yuzhnaya), as well as the retrofitting of TETs-9, TETs-11 and TETs-12 for the purpose of replacing obsolete equipment with modern gear. A provision has also been made for the construction of three new regional boiler facilities (RTS's) with a total thermal power of 1,200 GCal/h.

The overall thermal power of the TETs's by 1990 will amount to 36,300 GCal/h, the RTS capacity will be 6,500 GCal/h, while the scope of consumers encompassed by the heating supply will amount to 75 percent, and those encompassed by the centralized heat supply from RTS's will amount to 15 percent.

It is recommended that the dual pipe closed system for the centralized heat supply with the separation of hot water for domestic needs in water-water preheaters installed at the consumers be retained. Centralized quality control of the heat output from TETs's at a maximum design temperature of the mains water of 150° C is being retained.

The expansion of the heating networks was based on the conditions for improving the reliability and quality of the heat supply with backup of trunk lines with $D_y$ = 500-1,400 mm. Measures are provided to improve the controllability of the heating networks by means of constructing special monitor and distribution stations with a capacity of 20-40 GCal/h in regions of the city where consumers are connected through small heating points, as well as constructing large heating centers in new regions of the city.

The heating lines will continue to be run primarily underground in impassable and semi-impassable channels. The overall volume of heating network construction in the period 1976-1980 is: 408 km of water heating lines, 28.3 km of steam lines and 54 pumping and booster pump stations.

The work is determined by the necessity of designing an automated system for dispatcher control of the heating network, and the technical equipment for outfitting the dispatcher control facilities has been established.

The scientific and engineering committee approved the heat supply plan for Moscow based on the variant of maximum central heating using organic fuel. To supply heat to the city over the period 1981-1985, it was recommended that the TETs-21, TETs-23, TETs-25 and TETs-26 be provided with eight power units having T-250/300-240 turbines and advanced hot water boilers, as well as the construction of two RTS's with a thermal capacity of 800 GCal/h. It was also recognized as expedient to shorten the timeframes for the modernization of the TETs-9, TETs-11 and TETs-12, and to complete it in the 11th Five-Year Plan.

For the purpose of producing favorable ecological conditions for the capitol of the USSR, Moscow, the scientific and engineering council recommended changing the Moscow TETs-11, 12, 16 and 20 over from coal to gas, and setting up low sulfur fuel oil as the standby fuel. The burning of coal is to be retained at TETs-22. In 1979, the institute of Energoset'proyekt [Power Network Planning Administration] was assigned the development of a scheme for the fuel supply of Moscow TETs's over 1981-1990, tying it in to the overall fuel and energy balance sheet for the European portion of the USSR, and providing measures to improve the structure of the fuel balance sheet for the purpose of reducing harmful emissions and to assure reliability in the fuel supply of the Moscow TETs's.

It was recognized as necessary for the purpose of the timely resolution of questions of the heat supply for Moscow after 1990 for the TEO [not further defined] to construct nuclear heat sources for Moscow. In its decision, the scientific and engineering council turned to the USSR GOSSTROY with a request: consider and resolve the question of improving the heating and physical properties of residential and industrial buildings for the purpose of reducing heat losses by the buildings and curtailing fuel consumption for heating sources;

--Assure the introduction in an extremely short period of high quality protection of piping from external corrosion by means of enameling the piping, for which the construction of the requisite production facilities in the Glavmosinzhstroy system;

--Review the design outside air temperature for Moscow for the heat supply project planning (-25° C) in the direction of a decrease.

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ELECTRIC POWER AND POWER EQUIPMENT

UDC 620.91:621.1

## DEVELOPMENT OF CENTRAL HEATING

Moscow ELEKTRICHESKIYE STANTSII in Russian No 11, Nov 79 pp 2-4

/Article by Candidate of Technical Sciences G. G. Yakovlev and engineers S. B. Loshak and I. V. Markov, Soyuztekhenergo: "The Status and Prospects of Development of Central Heating in the USSR"/

/Text/ At the present stage of development of power engineering the economical and efficient consumption of fuel and power resources is of enormous national economic importance. In the decree of the CPSU Central Committee and the USSR Council of Ministers, "On Providing the National Economy and the Population With Fuel, Electric Power and Thermal Energy During the Fall-Winter Period of 1979/80," it is emphasized that the reliable supply of the national economy and the population with fuel, electric power and thermal energy is the most important state task of USSR ministries and departments, the councils of ministers of the union and autonomous republics, party and soviet organs, economic organizations and enterprises.

A decisive role in this matter is assigned to the USSR Ministry of Power and Electrification, which accounts for more than 92 percent of the electric power generated in the country, the output of one-third of the total heat used in the national economy and more than two-fifths of the heat used in cities and at industrial centers. The scale of our power engineering is making this task especially important.

The installed capacity of the electric power stations of the USSR Ministry of Power and Electrification at the beginning of 1979 reached 218.3 million kW, including 165.5 million kW at thermal electric power stations powered by organic fuel. The generation of electric power in 1978 was 1,110,700,000,000 kWh, including 909.9 billion kWh at thermal electric power stations powered by organic fuel. The annual increase of the generation of electric power by thermal electric power stations was 17.4 billion kWh, or 2 percent.

All the power plants of the USSR Ministry of Power and Electrification during the past year generated 813.4 million gigacalories of heat, of them 754.4 million gigacalories were generated by thermal electric power stations, including 642.9 million gigacalories, or more than 78 percent, by means of the exhaust steam of turbines. The annual increase of the output of heat for the USSR Ministry of Power and Electrification was 41.2 million gigacalories, or more than 5 percent.

In conformity with the decree of the CPSU Central Committee and the USSR Council of Ministers the USSR Ministry of Power and Electrification has been commissioned to ensure the elaboration and implementation of measures on the saving of fuel, electric power, thermal energy and petroleum products and the organization of the strictest monitoring of their rational use.

Much organizational and technical work on the more efficient and careful use of fuel and power resources is being performed at electric power station and in the power systems.

In 1978/79, especially during the period of the autumn-winter maximum, the assurance of the supply of electric power and heat to the national economy and the population took place under tighter conditions than in preceding years. This was caused by a scarcity of some types of fuel and by unfavorable weather conditions, which required during some periods higher than usual heat loads. Considerable harm in supplying energy to consumers was caused by the poor preparation of some power enterprises, heat and electric power networks for operation under winter conditions. This should not be repeated this year. In the decree of the CPSU Central Committee and the USSR Council of Ministers it was indicated that before the start of the fall-winter period of 1979/80 the heat networks, the heating, ventilation and hot water systems should be put in order at each enterprise and organization, residential, production and public buildings should also be heated. The USSR Ministry of Power and Electrification has been commissioned to bring the plan of generation in line with the assignment on the saving of electric power, to draft and implement measures on the increase of the reliability of the supply of electric power and thermal energy, as well as to increasing the monitoring of and responsibility for the saving of energy by consumers. Such measures were elaborated, several orders of the USSR Ministry of Power and Electrification have been issued in accordance with the results of the work during the autumn-winter period of 1978/79, their steady fulfillment should ensure the reliable supply of energy to consumers.

In 1978 the specific consumption of fuel at the electric power stations of the USSR Ministry of Power and Electrification was 331.1 g/kWh and decreased as compared with the preceding year by 3.3 g/kWh. A decrease of the specific consumption of fuel for the released electric power for the USSR Ministry of Power and Electrification as a whole was achieved: by means of the improvement of the pattern of generation of electric power in the condensation cycle by 1.2 g/kWh, the increase of the degree of economy of the operation of the equipment of electric power stations by 0.6 g/kWh and by the increase of the proportion of the generation of electric power in the central heating cycle by 1.5 g/kWh. As we see, the use of the cogeneration of electric power and heat at heat and electric power stations is the most important direction of the saving of fuel.

The cogeneration of thermal energy and electric power provides a saving of fuel not only because the specific consumption of fuel on the generation of electric power decreases, but also because small boiler houses, the number of which in the country exceeds 100,000, are being replaced. At present heat and electric power stations have an average specific consumption of fuel of 266.6 g/kWh, while condensation electric power stations have one of 358.2 g/kWh. The overall impact from central heating in the USSR during 1978 is rated by the saving of 30 million tons of conventional fuel. A further saving of fuel can be achieved by means of the better loading of the takeoffs of the turbines by means of additional connections of the users of heat.

An increase of the effectiveness of central heating is being achieved by increasing the unit capacity of central heating turbines and the parameters of the live steam. At present 10 turbines with a rating of 250 MW operating on a steam pressure of 240 kgf/cm$^2$, as well as a large number of powerful central heating turbines operating on a pressure of 130 kgf/cm$^2$ with a total capacity of 32.6 million kW are in operation.

Centralized heat supply systems have been developed in 800 cities of the country. The total length of the operating heating networks exceeds 180,000 km, of them about 20,000 km are on the balance of the USSR Ministry of Power and Electrification.

In connection with the policy of centralizing the supply of heat from powerful heat sources--heat and electric power stations--and with the increase of the length of the main and consumer heating networks the problems of increasing the reliability of heat supply systems are assuming greater and greater urgency. This problem should be solved comprehensively. At the stage of designing it is necessary to select properly and soundly the sources of heat with allowance made for the indicators of their reliability, their location in the heat supply system and the possibility of building a reserve.

The operation of heat supply systems under the extreme conditions of the past winter revealed the existence of shortcomings in the area of the designing and construction, as well as in the organization of the operation and management of centralized heat supply. There are also complaints against the plants which manufacture equipment and materials and the scientific research institutes which work in this area of power engineering. Many shortcomings are governed by the underestimation of the importance of questions of heat supply in the planning and supply organs of the country and by the departmental approach.

The need to make specific and revise some standard statutes, in particular, the construction norms and regulations, the technical operating rules, the norms of the technological designing of thermal electric power stations and heating networks, instructions on the water treatment and water-chemical conditions of heating networks and others was revealed in the process of analyzing the formed unfavorable situation with the supply of heat to the consumers of a number of cities of the country during the period of a sharp decrease of the outdoor temperature.

To a considerable extent the decrease of the reliability of heat supply is explained by the inadequate production of some components of equipment and materials, which are necessary for the sources of heat, heating networks and the systems of consumers (pipes, corrugated expansion joints, corrosion-proof materials, devices, special transport). The production volume of pipe with corrosion-proof enamel coating, equipment for automatic control and protection, remote control, instruments for recording and monitoring is entirely inadequate.

There is not an adequate scientific and experimental reserve in the area of heat supply, particularly on the study of the parallel operation of the heat supply system for general heating networks, on the water condition, on the one-pipe transportation of heat and on the conversion of heating networks to automated control systems. There are no studies of the problems of transporting water and heat from nuclear electric power stations, many problems of increasing the maneuverability of heat and electric power stations have not been solved. Scientific research institutes and the power engineering community must expedite the solution of the scientific and technical problems connected with the development of central heating.

The long-range plan of the USSR Minister of Power and Electrification calls for the further development of central heating both in the eastern regions and in the European part of the country.

The further increase of the capacity at heat and electric power stations by means of the installation of turbines with a capacity of up to 180 MW, which operate on a steam pressure of 130 kgf/cm$^2$, is being proposed. The already assimilated T-250 units, which operate on a pressure of 240 kgf/cm$^2$, will be used for major heating heat and electric power stations.

Taking into account the shortage of organic fuel in the European part of the country and on the basis of the conditions of environmental protection, the main directions of the development of central heating must be determined correctly, by choosing wisely the most efficient sources of heat (boiler houses, heat and electric power stations, nuclear heat and electric power stations).

The extensive use of atomic energy in the sphere of heat supply and the building of nuclear heat and electric power stations (ATETs's) and nuclear industrial stations (APS's) are an effective direction in the European part of the country. Nuclear industrial stations, which are located in the immediate vicinity of the users of steam, solve in the most efficient manner the problem of supplying steam and heat to industrial enterprises and nearby centers of population. Each nuclear industrial station with a capacity of 1,000 gigacalories/hr makes it possible to free annually approximately 600,000 tons of organic fuel in terms of conventional fuel.

Nuclear heat and electric power stations are the most economical sources of heat and electric power supply. Along with saving expenditures they ensure the greatest supplanting of organic fuel (2.5 million tons of conventional fuel a year per 1 million kW of installed capacity).

At the same time as the introduction of nuclear heat supply systems, when determining the technical policy of the development of central heating in the European part of the country up to 1990, serious attention should also be devoted to such well-known directions as the use of the condensation electric power stations and nuclear electric power stations, which are in operation and under construction, for central heating.

So far more than 100 turbines have been converted to the central heating mode. Plans for the redesigning of 160-, 200- and 300-MW condensing turbines with the output from them of 120-200 gigacalories/hr have been drafted. A number of versions of the plans ensure the output of heat without a substantial reduction of the electric capacity.

The use of GRES's for central heating is a substantial reserve for increasing the cogeneration of power with the minimum expenditures.

The orientation of the national economy of the eastern regions of the country toward the development of such heat-consuming industries as the chemical and petrochemical industries, the pulp and paper industry and the wood chemical industry, as well as the severe climatic conditions dictate the accelerated increase of heat consumption and its concentration. Taking into account the availability of relatively cheap fuel in sufficient quantities, the great demand for electric power and the need to improve the polluted air basin of cities, the orientation toward the maximum development of central heating in the eastern regions and toward the building of heat and electric power stations powered by solid fuel is becoming obvious.

The modernization of 25 heat and electric power stations (the increase of the productivity and degree of economy of water heaters, the conversion to a reduced vacuum and the increase of the takeoff capacity of the turbines, the installation of boilers, the modernization of accessory equipment and heating circuits) is called for in conformity with the plan of measures on the use of the thermal output and the increase of the operating efficiency of heat and electric power stations. This will provide a saving of 800,000 tons of conventional fuel a year with fewer expenditures than with the building of new heat and electric power stations.

An increase of the number of large boiler houses is planned in the centralized heat supply system. As compared with the use of small boiler houses this will make it possible to achieve an increase of the saving of fuel.

Along with the assurance of an increase of the sources of heat supply and the development of heating networks the reduction of the nonproductive losses of heat among consumers is playing an important role in saving fuel and power resources. Consumers account for 70 percent of the heat losses, the sources of heat supply account for 25 percent and 5 percent is lost while being transported.

Heat is being used inefficiently not only in industry, but also in the housing and municipal sector. It is possible to reduce heat consumption in the housing and municipal sector by 25 percent by means of the reduction of the area of openings for light, the use of triple windows, the increase of the heat resistance of the material of external barriers and the internal releases of heat. Changes in designing and construction both in the housing and municipal sector and in industry are necessary for this.

Considerable reserves for increasing the degree of economy of the operation of heat supply systems are formed by the level of automation and tele-automation. For example, it is possible to reduce the consumption of heat by 2-3 percent and correspondingly save fuel by the elimination of spring reheatings alone.

The most correct solution of a number of problems should be found in connection with the further long-term development of central heating and the extensive construction of heating networks.

It is possible to group with these problems:

the method of laying heating conduits (in indirect underground trenches, in through collecting mains or without trenches);

the protection of pipes against corrosion;

the efficient use of open and closed heat supply systems;

the assurance of reliable heat supply by various means of backing up the sources of heat;

the automatic control and protection of heat supply systems;

the introduction of the transportation of heat over long distances and the single-pipe transportation of heat;

questions of environmental protection when building heat and electric power stations and large boiler houses in cities;

the assurance of the reliable operation of peak-load hot-water boilers.

The collectives of scientific research, planning and operating organizations, as well as public scientific and technical organizations should be aimed toward the solution of these questions.

The unquestionable advantages of the combined method of generating heat and electric power are now recognized throughout the world. Central heating is being introduced more and more extensively in the economies of the socialist and capitalist countries. Central heating systems are becoming more complex and are being enlarged. The scientists of various countries are working productively on the improvement of the systems and on the development of new, more economic equipment in the area of central heating.

Central heating has become an integral part of USSR power engineering and is one of the main sources of the increase of efficiency in the sector.

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# ELECTRIC POWER AND POWER EQUIPMENT

UDC 621.31:620.91:662.2.001.2

## ELECTRIC POWER STATIONS OF EKIBASTUZ COMPLEX

Moscow ELEKTRICHESKIYE STANTSII in Russian No 11, Nov 79 pp 5-9

/Article by engineers V. N. Okhotin and A. A. Titov, All-Union State Institute for the Planning of Electric Equipment for Heat Engineering Structures: "Design Decisions of the Power Engineering Section of the Ekibastuz Fuel and Power Complex"/

/Text/ The power engineering section of the Ekibastuz Fuel and Power Complex consists of four similar GRES's with a capacity of 4 million kW each, new powerful substations and electric power transmission lines, a centralized system of operational and repair service and a centralized construction and installation base with the structures of the centralized control of the GRES's, a housing, municipal, cultural and general complex and other facilities.

The design decisions of all the electric power stations of the complex have been standardized on the basis of the improvement of the design decisions of the Ekibastuzskaya GRES-1, which is under construction (Figure 1 /photograph not reproduced/) in the following main directions: the increase of the use of effective construction materials and components, the combination of structural components and equipment for installation, the interconnection of auxiliary buildings and structures, the centralization of construction and installation operations, the centralization of operation and repair work and others. These decisions made it possible to increase the degree of economy of the planning indicators as compared with the approved plan of the Ekibastuzskaya GRES-1 (Table).

All the main and accessory equipment of the 500-MW power block is located in a 60-m unit, which has been standardized in its layout. In addition to the eight standardized block units, the main building[1] also has a three-bay unit of a fixed butt, in which are located the stationwide equipment (the pumps of the acid wash, untreated water, the water-level maintenance of the heating networks, the heaters of the untreated water, the diesel generators and others), the machine workshops, the repair area for the complete laying out of the assemblies and parts of the turbo-units and the transformer during their repair and others. Two-bay units with repair areas and machine workshops in the machine, boiler and other departments are called for between turbo-units Nos 4 and 5, as well as at the temporary butt end. Additional repair areas also exist in the engine room in the unit of each block. The experience of assimilating the first series-produced 500-MW power block powered by Ekibastuz coal--block No 7 of the Troitskaya GRES--was taken into account when arranging the equipment.

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[1] I. A. Alekseyev, "The Solution by the All-Union State Institute for the Planning of Electric Equipment for Heat Engineering Structures of the Problems of Power Engineering in the Designing of Heat and Nuclear Electric Power Stations," ELEKTRICHESKIYE STANTSII, No 7, 1978.

| Indicator | Engineering plan of Ekibastuzskaya GRES-1 | |
|---|---|---|
| | Approved | Adjusted |
| Labor inputs on construction, man-days/kW. . . . . | 1.94 | 1.83 |
| Materials-output ratio, kg/kW. . . . . . . . . . . . | 145 | 75 |
| With steel, including hardware . . . . . . . . . . . | 25.3 | 19.6 |
| Prefabrication of structural components, percent . | 70 | 80 |
| Including fuel supply. . . . . . . . . . . . . . . . | 43 | 78 |
| Specific area of allocation of land, hectares/MW . | 0.75 | 0.57 |
| Unit cost of industrial construction, rubles/kW | 122.5 | 120.1 |
| Production cost of electric power, kopecks/kWh . . | 0.385 | 0.383 |

A turbo-unit with a K-500-240-3 turbine of the Khar'kov Turbogenerator Plant imeni S. M. Kirov and a TGV-500 generator of the Khar'kov Elektrotyazhmash Plant with their accessory equipment occupies 48 m of the unit of the power block, the remaining 12 m are used for the location of the modules of the 6- and 0.6-kV distribution systems for internal needs and for the laying out of the assemblies and parts of the turbo-unit during its repair. Bay windows, which project beyond row A by 6 m, are called for in order to ensure the easy removal of the rotors of the turbogenerator.

The deaeration stack with a span of 12 m is built into the boiler house and has freight and passenger elevators, which ensure the transportation of people and freight to all the levels of the deaeration stack, as well as to the roof of the machine shop and above the boilers.

A T-shaped single-shell boiler of the Podol'sk Machine Building Plant imeni S. Ordzhonikidze with a rating of 1,650 tons/hr, which was tested at blocks Nos 7 and 8 of the Troitskaya GRES, with its accessory equipment is being installed in the boiler unit of the power block. There are being grouped with the boiler eight hammer mills (four on each side), onto each of which coarse coal is fed from two transverse bin stacks (four bins in each), which are located along the sides of the combustion chamber of the boiler under its convection section at a great height.

The boiler and the turbo-unit, which is placed transversely in the engine room, are installed on a single axis, which ensures the symmetrical supply of all the lines from the boiler to the turbine.

The tunnels of the fuel supply conveyors and the fuel transfer units from them to the conveyors of the transverse bin stacks are located in a 15-m bay at the 41.1-m level. Tube air heaters are located lower, while the primary air blowers are located under them at the zero level.

In the next bay, which measures 24 m, four wet ash traps for each power block with their gas conduits and air ducts have been installed, as well as clinker air lifts for raising the clinker slurry to the 24-m level, from which the mixture is fed by gravity conduits to the ash dumps.

In the next bay, which also measures 24 m, there have been grouped: electrofilters from the 39.7-m level along the axis; at the 21.8-m level units for the collection and removal of the ash trapped by the electric filters; at the zero level blast fans, air recirculation fans, exhaust fans and the air heaters of the air lifts.

Thus, all the equipment of the power blocks is located in closed buildings, which is very important for the climatic conditions of the Ekibastuz Fuel and Power Complex; moreover, the building of a separate building for the exhaust fans was not required.

In order to ensure the reliable and continuous supply of the boilers with fuel the plans of the fuel supplies of all the electric power stations were designed as a unit with two independent systems with a productivity of 1,500 tons/hr each. Each fuel supply system is furnished with an unloader, a crushing building and a fuel storehouse.

The unloading of trains arriving at the GRES with fuel is provided for at unloaders with rotary car tippers like the VRS-125. Milling crushers have been installed above each bin for the crushing of the lumps of fuel, which have remained on the gratings of the bins under the car tippers.

The delivery of coal from the bins is accomplished by feeders with a belt width of 1,600 mm. Each feeder makes it possible to feed fuel onto the conveyor with a controlled discharge of 300, 450 and 900 tons/hr, which is achieved by a change in the speed of the belt.

The unloaders and all the transfer points have been equipped with suction systems in order to improve the sanitary and hygiene conditions and to reduce the pollution of the facilities and the environment during unloading. The removal of dust in heated buildings is called for by hydraulic washing.

The crushing of the fuel in the fuel supply loop will be carried out in the crushing building by four M20X20G hammer mills with a productivity of up to 800 tons/hr.

The use of a coal store with a two-week supply of fuel, which consists of two round tanks, which are equipped with continuously operating machines with a productivity of 1,500 tons/hr each, is a new engineering solution.

A high level of automation of the technological processes on the basis of modern automation equipment, which is produced by domestic industry, is called for at each electric power station of the Ekibastuz Fuel and Power Complex.

The 500-MW power blocks are being furnished with automatic power control systems, as well as with fully variable systems of the automatic control of technological processes, which ensure the maintenance of the parameters over a wide range of change in the loads by the automatic adjustment of the parameters, the dynamic adjustment of the regulators and the rearrangement of the pattern of the control circuits.

The automation of discrete control operations during the start-up, shutdown and change of the load of the blocks is being carried out on the basis of logical control devices and the discrimination of functional groups. The automation of discrete control ensures an increase of the quality of operation and reduces the damage from possible improper actions of the personnel during complicated start-up operations.

The monitoring of the technological process, engineering and technical and economic analyses both at the power blocks and at the electric power station as a whole are being automated and the exchange of data with automated control systems of a higher level is being ensured on the basis of the use of modern third generation computer equipment.

The geographical location of the electric power stations made it possible to create in the basin of the acrid Lake Karasor, which is located 11-22 km from the sites of the GRES's, a common ash dump for all the electric power stations, the capacity of which will provide an opportunity for the operation of all four GRES's for 100 years. In this case the construction of protective dikes and dams will not be required. The topographic conditions made it possible to organize the most reliable and economical gravity arrangement of the hydraulic transportation of the ash slurry to the ash dump with an estimated speed of the ash of 2.79 m/sec and a minimum speed of not less than 1.7 m/sec.

A unified recirculating industrial water supply system of the GRES has been adopted with water storage basin-coolers, which are being built on the basis of the existing lakes or basins, with their feeding from the Irtysh-Karaganda Canal. All the water storage basins are being designed with the use of deep water intakes and surface outlets of the warm water. The cooling water is fed from the deep water intake through reinforced concrete tunnels to the shore pumping station and from it through steel delivery water pipes 2,000 mm in diameter to the condensers of the turbines. The discharge of the warm water into the water storage basin is provided for through open offtakes.

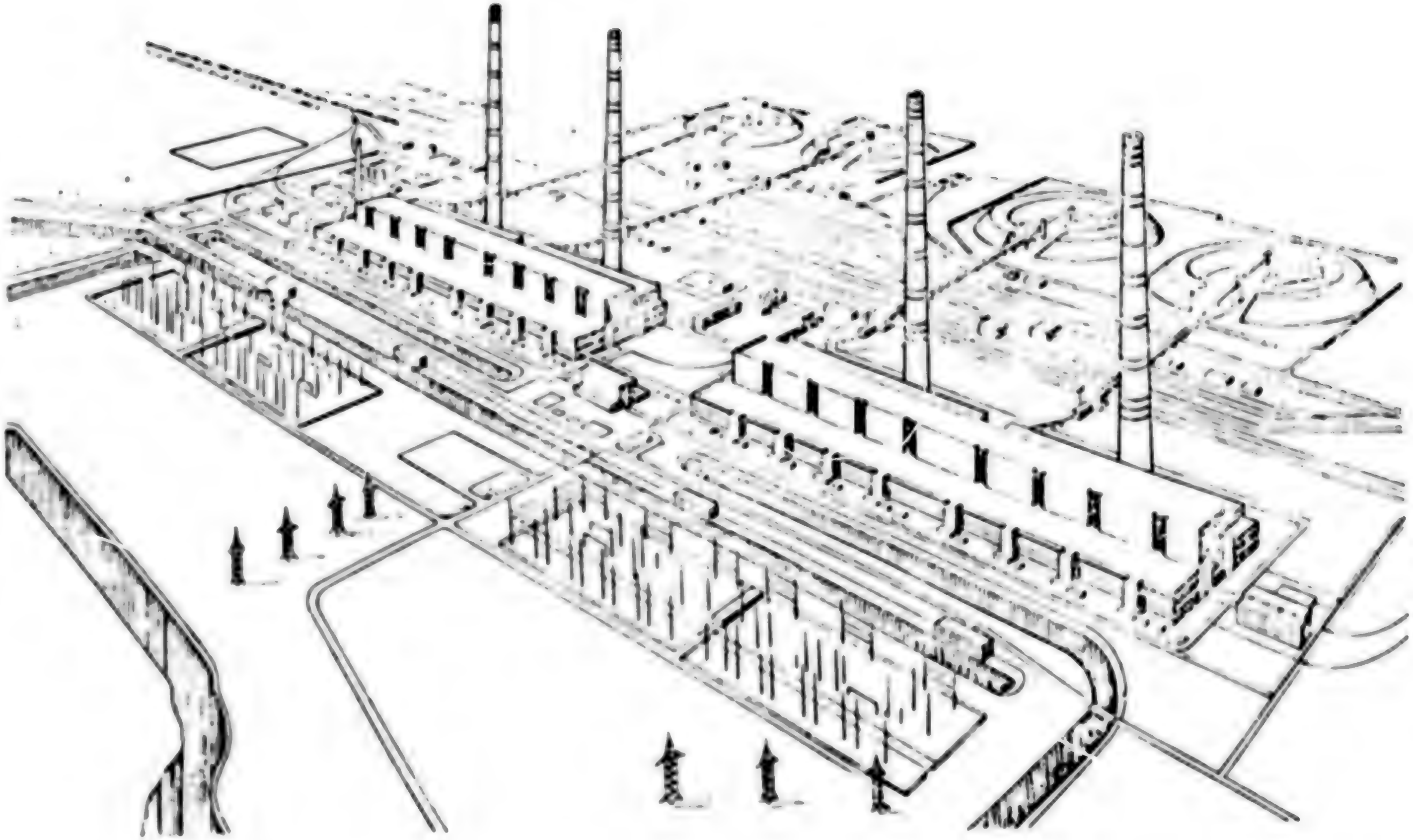

Figure 2. Version of the Layout of the Ekibastuzskaya GRES-2 and GRES-3

The further analysis of the general plan of the Ekibastuzskaya GRES-1 made it possible by means of interconnecting the auxiliary buildings and structures to reduce their number substantially (including those for fuel supply from 13 to 6), as well as to decrease by 9 percent the area of the site occupied by each GRES.

For the Ekibastuzskaya GRES-2 and GRES-3, the construction of which was called for at one water storage basin, a version of their location on one industrial site was worked out (Figure 2), which provides a reduction of the capital expenditures by 153 million rubles and a decrease of the area of the occupied land by 17 percent.

The location of the similar electric power stations, which have been planned for construction, with a maximum distance from each other of not more than 60 km, as well as the fact that all the power facilities are being built in a sparsely inhabited and rapidly developing region, governed the main direction--the centralization on a fundamentally new basis of the management of the operation, repair and construction of the electric power stations with centralized material and technical supply, the centralized supply of transportation and other centralized support.

In conformity with this the creation of a unified management of the Ekibastuzskaya GRES's is called for, in which the functions of administrative operations, operational (including adjustment and research operations), day-to-day maintenance and others are centralized. The centralization is based on an automated system of control of the power facilities and an automated system of control of operational activity. The functional organizational structure of management corresponds most completely to the conditions of the building of the Ekibastuz Fuel and Power Complex and the development of this sparsely inhabited region. It is common knowledge that the structure of foreign electric power stations is organized on a functional basis.

In recent years the functional structure (or its individual components) has begun to be introduced at operating domestic power enterprises. The experience of organizing cascades of hydroelectric power stations (the Daugavskiy, Srednedneprovskiy, Kubanskiy and others), the changeover of the regional power administration to the structure of a power production association, the experience of the Kazanskaya TETs-3, the Ufimskaya TETs-3, the Belovskaya and Sredneural'skaya GRES's are of interest on this level. The experience of more than three years of work with a functional structure of management of one of the largest electric power stations, the Litovskaya GRES with 300-MW power blocks, is of particular interest.

The functional organizational structure of the management of the electric power stations was developed by the All-Union State Institute for the Planning of Electric Equipment for Heat Engineering Structures in the engineering plan of the Ekibastuzskaya GRES-2 (Figure 3) and will be standard for all four GRES's. The structure of the unified management is presently being developed by Energonot with the participation of the Kazakh SSR Ministry of

Power and Electrification, the All-Union St[illegible] stitute for the Planning of Electric Equipment for Heat Engineering Structures, the All-Union Scientific Research Planning Institute of Power Systems and Electric Power Networks and others.

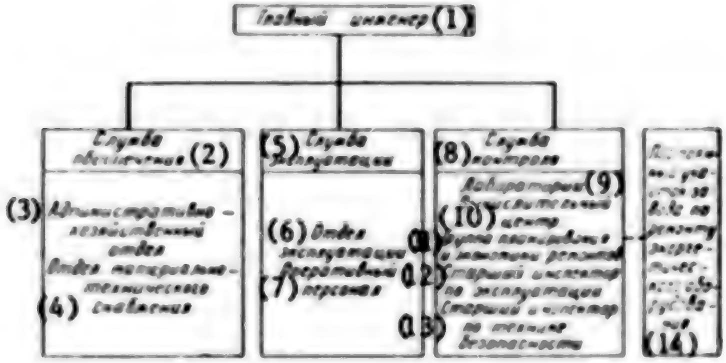
Главный инженер (1)
Служба обеспечения (2)
(3) Административно-хозяйственный отдел
Отдел материально-технического снабжения (4)
(5) Служба эксплуатации
(6) Отдел эксплуатации
Дежурный (7) персонал
(8) Служба контроля
Лаборатории (9)
(10) Вычислительный центр
(11) Группа планирования и экономики ремонтов
(12) Старший инспектор по эксплуатации
(13) Старший инспектор по технике безопасности
(14)

Figure 3. Functional Structure of the Management of the Ekibastuzskaya GRES's

Key:

1. Chief engineer
2. Support service
3. Administrative and operating division
4. Division of material and technical supply
5. Operation service
6. Operation division
7. Operations personnel
8. Inspection service
9. Laboratories
10. Computer center
11. Group for the planning and economics of repairs
12. Senior operations inspector
13. Senior inspector for labor safety practices
14. Permanent section of the power equipment repair plant

At the 25th party congress General Secretary of the CPSU Central Committee Comrade L. I. Brezhnev emphasized that "...far from all the ministries and departments are ready for the active development of specialization..., for the building of special plants for the production of tools and accessories, standardized assemblies and parts. The repair base has been scattered beyond all proportion. Such trends are leading to the considerable waste of all types of resources."

When designing the Ekibastuzskaya GRES's the institute departed from the practice established in the USSR Ministry of Power and Electrification (the separate designing of electric power stations and repair plants) for the purpose of solving comprehensively the problems of the operational, repair and other types of service of the electric power stations. As a result a system of the complete repair service of all the GRES's of the complex was developed. The power equipment repair plant, the distance from which to any GRES does not exceed 60 km, is the heart of this system its organizational and industrial basis. A plant section as such with a foundry with a capacity of up to 30,000 tons of founding a year and specialized works (a field section) for the repair of power equipment, control and measuring instruments, automatic equipment, buildings and structures and the restoration of the chemical coatings of equipment at the sites of the GRES's are being set up at the power equipment repair plant. In conformity with this central repair workshops, workshops of the repair and construction shop and central workshops for the repair of control and measuring instruments and automatic equipment are not being built at the sites of the GRES's, the central materials warehouses are being reduced significantly, to the size of operational warehouses, and others.

The industrial plant repair of portable equipment, as well as of assemblies and parts of unportable equipment constitutes about 20 percent of the entire volume of equipment repair, which will ensure the performance of repair operations at the GRES's mainly by the unit method with a reduction of the volume of these operations to 50 percent of the total volume of equipment repair. On the whole the repair work is being based on an exchange stock of equipment, spare parts, assemblies and parts, which is centralized at the power equipment repair plant, which ensures the constant year-round loading of the plant section.

The construction of the Ekibastuzskaya GRES's is being carried out by the high-speed flow line method, here the questions of organizing the construction and installation work have been solved in a new way. Instead of building at each GRES the traditional temporary structures and assembly yards, the total areas of which often exceed the industrial sites of the electric power stations being built by means of them (for the Zaporozhskaya GRES by 79 percent), a common regional production and procurement base for all of them is envisaged. It is a group of production complexes for the operation and maintenance of construction machinery, devices and means of transportation, the material and technical supply of the construction of the Ekibastuzskava GRES's, the procurement, warehousing and consolidated assembly of structural components and technological equipment.

The creation of the regional production and procurement base is making it possible to increase labor productivity by 8 percent and to improve the quality of work by means of greater specialization, the repetition of production operations and the significant approximation of the performance of a number of operations to plant conditions, including the assembly of a portion of the assembly blocks in covered buildings, which is especially important for the climatic conditions of Ekibastuz; to ensure the better loading of motor and rail transport and construction and installation machinery; to increase the utilization of skilled manpower and material and technical resources, to reduce the turnover of manpower; to centralize and reduce the stocks of materials at warehouses.

The organization of the flow line construction of the Ekibastuzskaya GRES's is creating the conditions for the uniform loading of the enterprises of the construction industry and the regional production and procurement base and for the consistent performance of similar operations in the construction of all the GRES's by the same subdivisions, which increases work quality; ensures the creation of project-by-project flows within a GRES during the construction of the buildings and their individual parts, which have a similar construction technology; provides for the performance of the operations by specialized organizations, which considerably increases labor productivity.

In the Main Directions of USSR National Economic Development for 1976-1980 it is noted: "To elaborate and implement measures on environmental protection, the efficient use and reproduction of natural resources."

Measures on the suppression of nitric oxides, a two-stage system of ash purification with an ash trapping efficiency of 99.5 percent and two smokestacks each 330-420 m high, which ensure the maximum gas and dust content from the emissions of the GRES's below the maximum permissible concentrations, are called for in order to protect the air basin of the region at each GRES. Moreover, in the plan of the ash dump provision is made for the washing of the ash banks with clayey soils to prevent the ash from turning into dust.

Measures on the maximum preservation of land which is valuable in agricultural use are also called for, including the removal and storage of the soil layer from the sites allocated for industrial construction; the recultivation of valuable lands; the reduction of the area of the valuable lands withdrawn for industrial construction (the common ash dump, the combining of the industrial sites of the GRES-2 and GRES-3) and others.

The systems of industrial water supply and hydraulic ash trapping use the internal-drainage basins of acrid intermittent lakes, which were not used due to the salinity of the water and soils either in fishing or in agricultural production. The plan envisages for the creation of a normal hydrochemical condition of the water storage basin-coolers their flushing before filling with the discharge of the soluble salts in the ash dump, and during the period of operation the constant purging of the industrial water supply systems in the amount of the irretrievable losses in the hydraulic ash removal system. The design decisions call for the creation at the water storage basin-coolers of recreation zones for the workers of the industrial region.

A unified system of special coal-carrier railroad tracks, over which the fuel will be hauled by heavily loaded trains, which have been formed from cars with a capacity of 12[illegible] tons, with the use of electric traction, with 15-17 trains per GRES a day, is being built to supply coal to the electric power stations.

The Ministry of the Coal Industry is drafting a general plan of the development of the train transport of the Ekibastuz Industrial Region, in which provision will be made for the efficient servicing of all the traffic of the power complex.

The release of the electric capacity from the Ekibastuzskaya GRES's is envisaged through the circuit of paired blocks to a 500-kV outdoor distribution system, with the exception of block No 1 (it operates on a 220-kV outdoor distribution system) and blocks Nos 2, 3 and 4 (they are switched through a one and one half circuit to a 500-kV outdoor distribution system). From the 220-kV and 500-kV outdoor distribution systems the capacity is feed to a 1,150-kV AC overhead line and the converter substation of a 1,500-kV DC overhead line. All four GRES's have links through the 500-kV outdoor distribution system. The adopted arrangement of the release of the capacity ensures the transmission of electric power for the development of the economy of Kazakhstan, to the central regions of the country, to the Urals, Central Asia and Western Siberia.

There were serious difficulties in the designing of such a complicated project as the power section of the Ekibastuz Fuel and Power Complex. Such difficulties also exist at present. One of them is the development of a water heater powered by Ekibastuz coal of inferior quality, which is being planned for the Ekibastuzskaya GRES-2, GRES-3 and GRES-4 in connection with the fact that the ash content of the coal is increasing to 48 percent with an overshoot to 53-55 percent.

At present the Podol'sk Machine Building Plant imeni Ordzhonikidze is working on the modernization of the P-57 boiler, so that it could satisfy the new conditions. The equipment of this boiler with medium-speed mills with a capacity of up to 65 tons/hr is envisaged. It is anticipated that the developments of the plant will make it possible to retain the main standard design decisions for the Ekibastuzskaya GRES's and the level of their technical and economic indicators.

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## ELECTRIC POWER AND POWER EQUIPMENT

UDC 621.039:697.34:338.984.2.001.13

# NUCLEAR SOURCES OF HEAT SUPPLY

Moscow ELEKTRICHESKIYE STANTSII in Russian No 11, Nov 79 pp 9-13

/Article by engineers V. P. Tatarnikov, Yu. A. Kuznetsov, G. I. Pleskov, All-Union Institute for the Planning of Electric Equipment for Heat Engineering Structures: "The Prospects and Means of the Development of Heat Supply From Nuclear Sources"/

/Text/ The present stage of development of electric power engineering in the USSR is characterized by the broadening of its fuel base by means of the use of nuclear fuel in generating electric power. Since at present up to 40 percent of the organic fuel is used for the production of thermal power, along with the extensive introduction of nuclear fuel for the generation of electric power its use for the purposes of the centralized supply of heat is of great interest.

The use of nuclear fuel for supplying heat to cities will make it possible to solve the problems of maintaining the cleanness of the environment and transporting fuel.

An increase of the demand for heat by nearly twofold as compared with 1975 is anticipated in our country by 1990. According to the structure of the heat loads the industrial heat consumers, among which the majority will have a predominant heating load in hot water, will be the main type of users.

At present in the European part of the USSR and in the Urals it is expedient to use nuclear heat and electric power stations (ATETs's), starting with a heat load in hot water of 1,500 gigacalories/hr and more, and nuclear heat supply stations--AST's (boiler houses)--within the limit of loads of 600-1,500 gigacalories/hr.

The tendency for the cost of organic fuel, and especially gaseous fuel and fuel oil, to increase, which has occurred in recent times, apparently will lead to a decrease of the competitive boundary of the minimum value of the heat loads which are covered from nuclear sources of heat supply.

The main design proposals, including the selection of equipment, and questions of the safety of the construction of ATETs's and AST's are examined below.

Nuclear Heat and Electric Power Stations. On the basis of the currently available operating experience and data on the reliability and radiation safety of nuclear electric power stations, plants with light-water reactors can be recommended for ATETs's during the period up to 1990.

Estimates have shown that the ATETs with a VVER-1000 react r has the best technical and economic indicators, and this type of reactor can apparently be recommended as the base version when choosing the plan of centralized heat supply from ATETs's for the period in question.

It is recommended to adopt a composition of the turbine equipment for first generation ATETs's on the basis of the capacity of the reactors with the possibility of creating the blocks reactor-turbine and reactor-two turbines.

Studies have shown that the use of turbines like the T-500-60 and TK-500-60 is necessary for ATETs's. The T-500-60 should have the following specifications: a pressure of the live steam of 60 kgf/cm$^2$; an electrical capacity of 500,000 kW, a rate of rotation of the shaft of 3,000 rpm, a steam consumption per turbine of 3,200 tons/hr, a maximum heat load of 900 gigacalories/hr. The TK-500-60 turbine has the same specifications, but a maximum heat load of 450 gigacalories/hr.

The main technical decisions on the arrangement of the structures of the main building of an ATETs are basically the same as for a conventional nuclear electric power station. The difference consists in the layout decisions for the engine room, which are dictated by the installation of central heating turbines.

A nuclear heat and electric power station with two VVER-1000 reactors and four TK-500 turbines can at most release to a consumer 1,800 gigacalories/hr of heat in hot water disregarding peak-load sources; an ATETs with the same reactors, but with T-500 reactors can release up to 3,600 gigacalories/hr.

The installation of the appropriate equipment at ATETs's can be recommended depending on the size of the heat loads of consumers for the center in question. In this case the choice of the basic equipment to a considerable extent will depend on the specific conditions of the region in which the construction of an ATETs is proposed.

The many years of experience of operating nuclear electric power stations in the USSR show that nuclear electric power stations with water-moderated water-cooled reactors during normal operation have a very low radioactivity of the coolant in the first loop, as well as minor discharges of radioactivity through the ventilation duct, which with allowance made for the 3-km health protection zone ensures the great safety of nuclear electric power stations with the virtual absence of an adverse influence on the environment and the population.

However, in spite of the existing experience, the estimated rating of the safety of ATETs's was made with very conservative premises about the condition of the fuel in the reactor and the radioactivity of the coolant and the equipment. Thus, when determining the radioactive emissions it was assumed that 1 percent of the fuel elements can has gas leakage and 0.1 percent of the fuel elements can have direct content of the uranium fuel with the coolant. The value of the disorganized leaks from the loop was taken as up to 200 l/hr. Here the estimated radioactivity of the coolant of the first loop was 0.1 Ci/l, while the experience of operating water-moderated water-cooled power reactors (the Novovoronezhskaya and Kol'skaya AES's) shows that the radioactivity of the coolant during operation does not exceed a value on the order of $10^{-3}$ Ci/l, that is, it is one one-hundredth of the value used in the estimate.

Even with the application of all the adverse premises used in the plan, as a result of the calculations it turned out that the operational emissions of the two blocks of an ATETs with a VVER-1000 are less than what is fixed by health standards.

Thus, in reality it can be expected that the total emission of radioactivity from an ATETs will be very negligible, less than a percent of the permissible amount.

In conformity with the requirements of the mentioned general principles of the assurance of the safety of nuclear electric power stations, the instantaneous lateral rupture of the main circulation pipe with a hypothetical diameter of 850 mm was regarded as the maximum accident. Various safety devices, which limit the damages to the reactor core, and localizing devices, which limit the spread of radioactive substances, are envisaged for assuring safety in the case of such an accident.

Among these systems are: emergency reactor shutdown systems; systems for the emergency pouring of coolant into the reactor core in case of a drop of pressure in the loop; sprinkler systems, which ensure a reduction of pressure and the bonding of radioactive iodine; a hermetic containment vessel, which is designed for a pressure of 5 $kgf/cm^2$. All the systems for assuring the safety of nuclear electric power stations have a high degree of redundancy--300 percent (3 X 100 percent)--and are completely independent of each other and of external power supply sources.

Calculations and experimental work show that the adopted measures prevent the melting of the fuel under the most difficult conditions, while the doses of internal and external irradiation of the population at the boundary of the health protection zone (3 km), given the examined maximum accident, will be a few percent of the permissible amounts.

Thus, the emissions of radioactivity even in case of such a hypothetical accident will be considerable less than what is set by standard documents.

The network water heating system at an ATETs eliminates the possibility of the radioactive contamination of the network water both during normal operation and in the case of accidents. For this provision is made at the ATETs for: a three-loop system for the release of heat; the heating of the network water with steam from the takeoffs of the turbine only through the heat-transfer surface of the network heaters; the maintenance of the pressure of the heating agent (the steam of the takeoffs) lower than the pressure of the network water; cut-off devices (delays), which automatically halt the feeding of steam to the heat exchangers in the case of the triggering of the emergency shielding of the reactor and in the case of the drop of the pressure of the network water lower than the pressure of the heating agent; dual delays on the network water mains, which shut down the central heating plant in case of the drop of the pressure of the network water lower than the pressure of the heating agent; the continuous monitoring of the radioactivity of the network water and the heating agent of the second loop with the sounding of the appropriate warning and alarm signals.

In addition to ATETs's with turbines of type T and TK, versions with the takeoff of steam for heating from the uncontrolled takeoffs of condensing turbines are also envisaged. These versions may be economically advisable when a large center of population is located close to a large-capacity nuclear electric power station.

Thus, depending on the specific conditions, nuclear heat and electric power stations with the installation of central heating turbines, condensing turbines with the controlled takeoff of steam and, finally, condensing turbines with the uncontrolled takeoff of steam may be economically advisable on the territory of the USSR. Obviously, the last two types are closest to the developed nuclear electric power station and it is advisable to build them first of all. The studies on ATETs's with their attachment to specific consumers have shown that the selection of the sites for their construction near major cities involves difficulties in providing water for industrial heat supply, on the removal from ATETs's of debalanced water and sewage and on the retirement, as a rule, of arable lands, which are used most effectively in agricultural production and others.

The possible versions of the main building (cross section) and the general plan of an ATETs are shown in Figures 1 and 2.

Nuclear Heat Supply Stations. One of the main problems in solving the questions of centralized heat supply from nuclear sources is the provision of the conditions for bringing them as close as possible to the users of thermal energy.

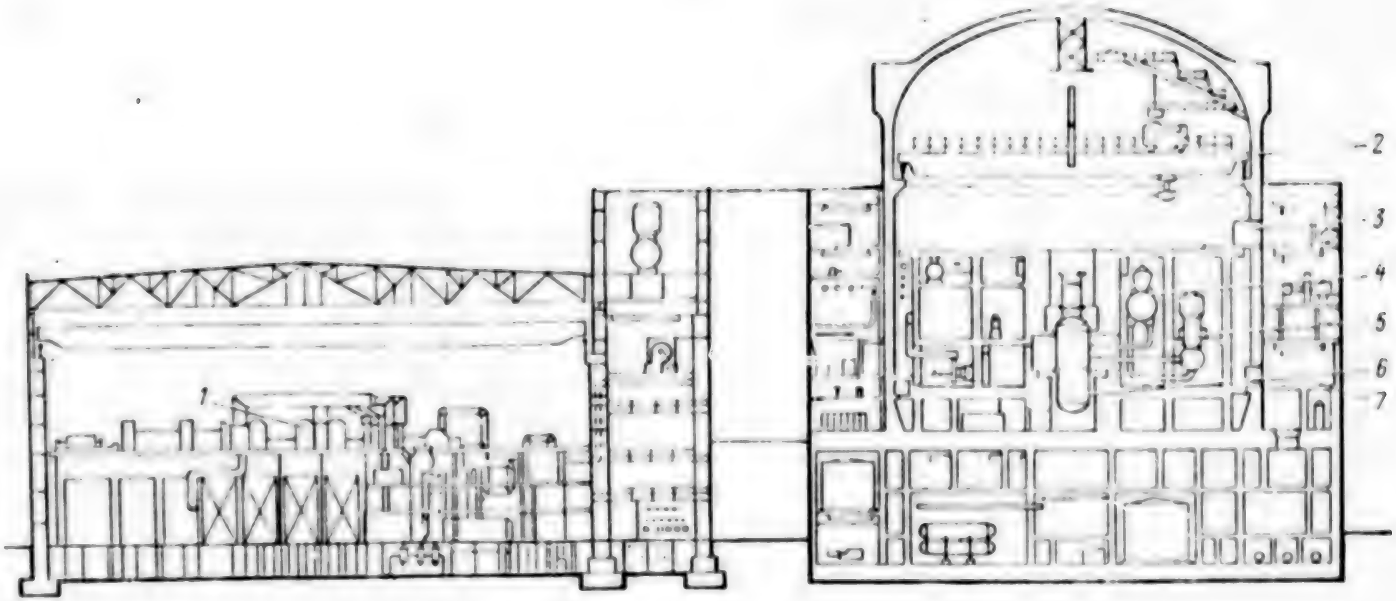

Figure 1. Arrangement of the Main Building of an ATETs (Cross Section)

1--turbo-unit; 2--hermetic vessel; 3--access lock; 4--steam generator; 5--main circulating pump; 6--reactor; 7--compartment of auxiliary systems.

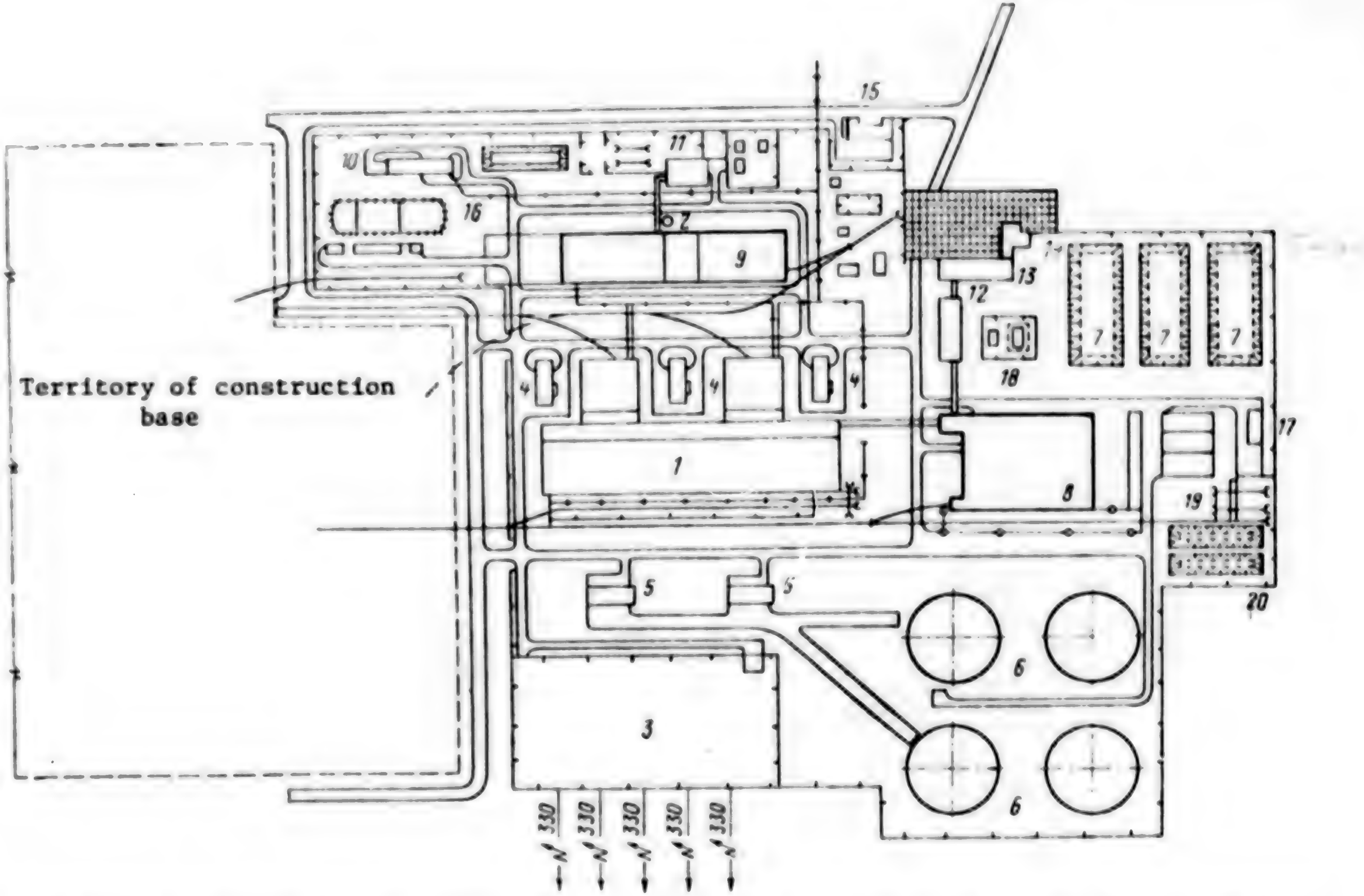

Figure 2. Schematic Drawing of the General Plan of an ATETs. 1--main building; 2--ventilation duct; 3--330-kV outdoor distribution system; 4--diesel electric power station; 5--block pumping station; 6--cooling towers; 7--sprinkling ponds of responsible users; 8--combined auxiliary building; 9--special building with "contaminated" workshops; 10--standby start-up boiler houses; 11--waste storage pit; 12--laboratory and general building; 13--administrative building; 14--dining room; 15--fire station; 16--fuel oil management; 17--management garage; 18--production and fire fighting water main; 19--warehouse of dry salts; 20--sludge dump

The design of a nuclear heat supply station, which is being studied with allowance made for the following general requirements: the assurance of the safety of the AST, which would make possible the location of the station in the immediate vicinity of the users of the heat; the maximum utilization in the plan of the existing equipment, machinery, instruments, materials, as well as the gained experience of designing, producing and operating plants with water-moderated water-cooled reactors, satisfies this condition to the greatest extent.

The reactor whould be an integrated water-moderated water-cooled device, which has been designed according to the principle "a vessel in a vessel" for assuring the safety of the AST in case of any accidents, up to the rupture of the vessel; the thermal output of the reactor is 500 MW (430 gigacalories/hr).

On the basis of economic considerations, the unit thermal output of the reactor is taken as the maximum for the upper level of the range of heat loads (600-1,500 gigacalories/hr), which have been recommended for covering from an AST, taking into consideration the installation at the station of two blocks with central heating coefficients of 0.55 to 1. In the future with the extension of the area of use of atomic power for the purpose of centralized heat supply the development of reactors of a smaller capacity (200-300 gigacalories/hr) might be required to cover smaller heat loads. However, under certain conditions the version of the installation at AST's of one block each with a capacity of 430 gigacalories/hr with the assurance of the redundancy of the output of heat by means of the installation of special standby peak-load boiler houses powered by organic fuel is also not ruled out.

The technological arrangement of the block of the reactor plant is a three-loop arrangement: the main, intermediate and network loops. Water under pressure is used as the coolants in all the loops.

The main loop is a radioactive loop, with the natural circulation of the coolant. The approximate parameters of the coolant of the main loop at 100 percent capacity are: pressure--16 kgf/cm$^2$, temperature at input into the core--165°C, on leaving it--200°C.

The intermediate loop is not radioactive and is made from three loops of the takeoff of heat from the reactor and its transfer to the network water. The pressure of the coolant in the intermediate loop upstream from the network heaters is 12 kgf/cm$^2$; the temperature on entering the heat exchangers is 90°C and on leaving them it is 170°C.

The water pressure in the network heaters is 16 kgf/cm$^2$, the water temperature on entering the heater and on leaving it is respectively 70°C and 170°C. The consumption of network water in the heating mains from the AST will be about 10,000 tons/hr.

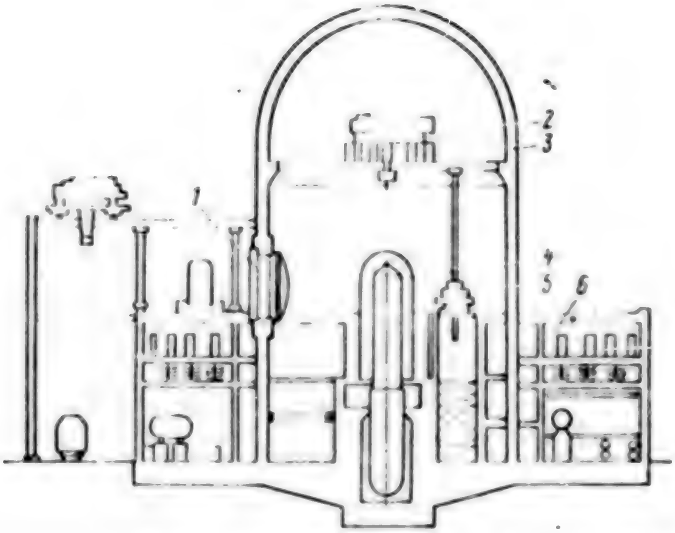

Figure 3. Arrangement of the Main Building of an AST (Cross Section)

1--hatch; 2--cock; 3--hermetic vessel; 4--reactor plant; 5--lifting machine; 6--compartment of auxiliary systems

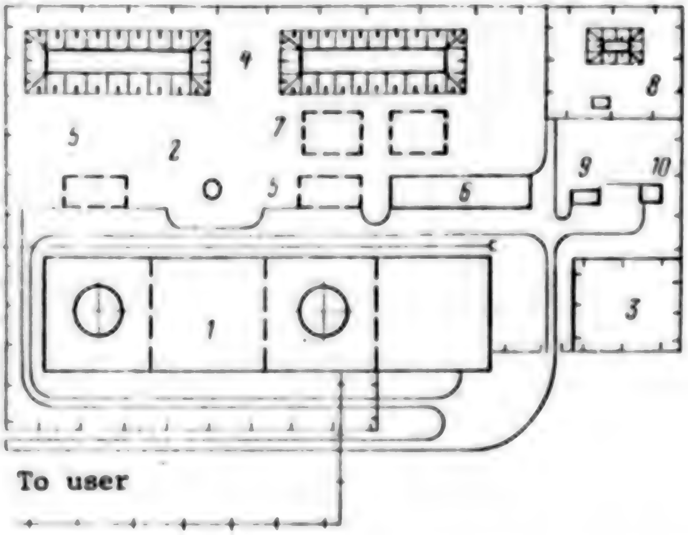

Figure 4. Schematic Drawing of the General Plan of an AST

1--main building; 2--ventilation duct; 3--substation; 4--sprinkling pond; 5--diesel generator station; 6--compressor house, garage; 7--reservoir of industrial water; 8--water works; 9--oxyacetylene plant; 10--sewage pump house

The possible versions of the main building (cross section) and the general plan of an AST are shown in Figures 3 and 4. The arrangement of the AST in all the versions is being developed with allowance made for special safety requirements.

The proximity of the AST to large cities and the connection of the users with the station through network water urgently raise the problem of radiation safety. The assurance of safety during normal operation and in emergency situations and the complete elimination of the possibility of radioactivity entering the network water are its main requirements.

Calculations show that the dose of irradiation at the boundary of the health protection zone during the normal operation of an AST from the discharge of radioactive products through the ventilation duct will be less than a percent of the dose created by the natural background locally.

In case of the emergence of the worst emergency situation, including the rupture of the reactor vessel, owing to the integrated configuration of the reactor and the complete flooding of the core, the failure of the jacket of the fuel elements does not occur, and the maximum radioactivity, which can be released into the sealed compartments, does not exceed the radioactivity contained in the coolants of the main loop.

The reliability of the cooling of the reactor core is achieved by the natural circulation of the coolant of the main loop. The greater safety of an AST is ensured by the placement of the reactor vessel in a containment vessel, which is designed for the same pressure as the coolant.

Among the measures, which ensure the protection of the network water against the penetration of radioactivity into it, are: a three-loop arrangement of the transfer of heat to the network water; the constant purging of the intermediate loop with the constant monitoring of the radioactivity in it and the shutting off of the loop in case of its appearance; the maintenance of a higher pressure in the network loop than in the intermediate loop, which eliminates the penetration of radioactive water into the heating network even in the case of the accidental leakage of the network heat exchangers; the disconnection of the users of heat from the AST in case of a drop of pressure in the heating network with the simultaneous seal failure of the surface of the network heater.

The technical and economic comparison of the versions of heat supply sources powered by organic and nuclear fuel shows: the nuclear heat supply station is competitive with respect to the coal-powered heat and electric power station and the nuclear heat and electric power station with power blocks of 500 MW each and is slightly inferior to ATETs's with blocks of 1,000 MW each; the amount of conventional organic fuel, which is replaced by AST's with two 500-MW (heat) blocks, is 800,000 tons/year.

The nuclear heat supply station as compared with other possible sources of centralized heat supply has a large number of advantages, since the low parameters of the coolants and the relatively small capacity of the reactor plant makes it possible to substantially simplify the design of the reactor and to ensure a greater safety of the AST; to bring the AST to a distance of 2-3 km from major heat users.

The assurance of the radioactive safety of the nuclear heat supply station, its economic efficiency and the enumerated merits make it possible to consider the AST a promising source of the centralized heat supply of the complexes of housing, municipal and industrial users.

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## ELECTRIC POWER AND POWER EQUIPMENT

UDC /621.311.25:621.039/.036.2

# OPERATION OF NUCLEAR HEAT SUPPLY STATIONS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 11, Nov 79 pp 13-15

/Article by Candidate of Technical Sciences V. S. Bunin and engineer A. A. Kudryavtsev, All-Union Institute of Heat Engineering imeni F. E. Dzerzhinskiy: "On the Use of Nuclear Heat Supply Stations"/

/Text/ The use of nuclear fuel not only in the generation of electric power, but also in the production of heat for centralized heat supply is one of the efficient ways of improving the fuel and power balance of the country.

Nuclear fuel yields the greatest impact when it is used at nuclear heat and electric power stations, since in this case a considerable share of the electric power is generated on the basis of heat consumption with low specific consumptions of heat. However, in some cases the use of nuclear heat supply stations (AST's) can also be economically justified.

The advisability of the construction of AST's is determined not only by economic considerations, but also by other important factors, the main ones of which are the following:

the conditions for the selection of the construction sites for AST's, which do not require water resources and additional capital investments in the construction of industrial water supply systems, are made considerably easier;

the greater radiation safety of the AST as compared with the nuclear heat and electric power station (ATETs), which makes it possible to locate it at a negligible distance from the center of the use of heat;

the design studies of ATETs's, which are located in accordance with the norms of radiation safety at a distance of 25-30 km from the boundary of the heat using region, showed that the capital investments in the transit heating networks are approximately 15 percent of the cost of the station. The construction of an AST in the immediate vicinity of the boundary of a city eliminates these expenditures and releases a considerable amount of large-diameter piping;

the relatively small size of the required areas, less pollution of the environment by harmful discharges under normal and emergency operating conditions.

The main economic indicator, which determines the efficient area of the use of AST's as compared with other heat supply sources (boiler houses powered by organic fuel, heat and electric power stations, ATETs's), is the cost of their construction. The first design studies of AST's showed that their unit cost exceeds by several times the unit cost of boiler houses powered by organic fuel. One of the possible means of increasing the efficiency of the AST is the increase of the utilization ratio of its installed capacity, which can be achieved with the joint operation of an AST and peak-load hot water boiler houses powered by organic fuel, which ensure the covering of the peak part of the curve of the heat load of a region.

Technical and economic studies show that there is an optimum ratio between the estimated heat loads of a region and the AST $\alpha_{AST}$, in case of which the use of the latter is the most efficient. The meeting of the peak part of the curve of the heat load of a region by means of peak-load sources powered by organic fuel makes it possible to increase the life of the AST with a nominal power and to decrease the influence of the daily fluctuations of the load of hot water supply on the conditions of its operation. Here, the lower the value of the coefficient $\alpha_{AST}$ is, the longer the period of operation of the reators of an AST with a nominal output is. However, the decrease of $\alpha_{AST}$ with a given heat load of a region leads, on the one hand, to the decrease of the required unit capacity of the reactors of the AST's, which increases their unit cost, and, on the other, to an increase of the annual consumption of organic fuel at the peak-load sources and to additional operating costs.

In the studies made on determining the optimum coefficient $\alpha_{AST}$ the following initial data were used:

the main parameters of the reactor plant of the AST were taken according to the materials of the design of the reactor with a unit capacity of 500 MW (430 gigacalories/hr);

the estimated heat load of the region was take to be equal to 1,500, 2,000 and 2,500 MW, which requires the installation at the AST when $\alpha_{AST} = 1$ respectively of three, four and five 500-MW reactors;

the use of gas and fuel oil water boilers was proposed as the peak-load source;

the cost of organic fuel ranged from 30 to 60 rubles/ton of conventional fuel;

the specific capital investments in hot water boiler houses were taken depending on their thermal output and ranged from 20,000 to 30,000 rubles per gigacalorie;

the specific capital investments in the AST were taken in accordance with the expert estimates of the authors with the use of the available design studies and ranged depending on the thermal output from 90,000 to 180,000 rubles per gigacalorie.

The installation of a standby hot water boiler house with a capacity equal to the unit capacity of the reactor of the AST was envisaged for the purpose of ensuring the reliability of heat supply.

The curves of the changes in the annual adjusted estimated expenditures in supplying heat from an AST depending on the coefficient $\alpha_{AST}$, the estimated heat load and the cost of organic fuel are constructed in Figure 1.

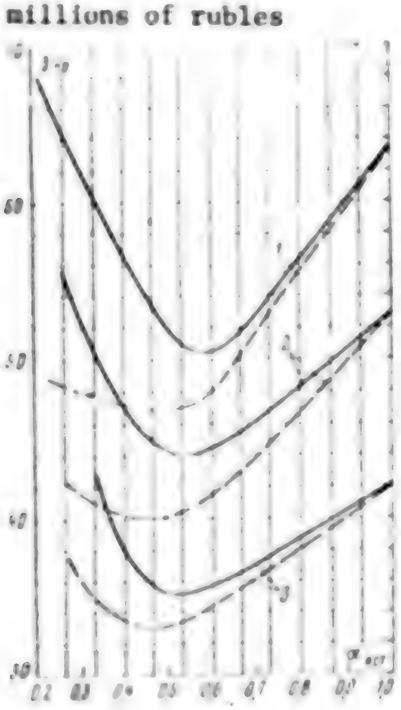

Figure 1. Curves of the Dependence of the Change of the Adjusted Expenditures at an AST on the Coefficient $\alpha_{AST}$, the Heat Load of the Region and the Cost of Organic Fuel.

1, 2, 3--the load of the region of 2,500, 2,000 and 1,500 MW; —— is the cost of organic fuel of 60 rubles/ton of conventional fuel; - - - - is the cost of organic fuel of 30 rubles/ton of conventional fuel.

The optimum value of the coefficient $\alpha_{AST}$ in the examined range of loads changes negligibly and lies in the range of 0.4-0.6. A deviation from the optimum value of $\alpha_{AST}$ leads to a considerable increase of the adjusted estimated expenditures. Thus, with a heat load of the region of 2,000 MW and a cost of organic fuel of 30 rubles/ton the deviation from the optimum value of $\alpha_{AST} = 0.45$ to 1.0 leads to the exceeding of the estimated expenditures by 13 million rubles, or 35 percent.

The advisability of constructing an AST for heat supply to one region or another in the end should be determined as a result of the technical and economic comparison with other sources of heat, particularly heat and electric power stations, ATETs's and boiler houses powered by organic fuel. The estimates show that in regions with a heat load of 1,500-2,000 MW and more AST's are considerably less efficient than ATETs's, therefore the comparison of AST's with hot water boiler houses powered by organic fuel is of particular interest. On this level the decisive indicator is the amount of the maximum specific capital investments in AST's, in case of which the heat sources being compared become equally efficient.

The technical and economic studies on determining the maximum specific capital investments in AST's were made with the following initial data:

the estimated heat load of the region was taken to be equal to 1,000, 2,000, 3,000 and 4,000 MW, which with $\alpha_{AST} = 0.5$ requires the installation at the AST correspondingly of 1 to 4 reactors with a capacity of 500 MW each;

the cost of organic fuel was taken as 20 to 60 rubles/ton of conventional fuel;

the use of gas and fuel oil hot water boilers as the peak-load boilers in the versions of the AST and as the main boilers in the versions of the regional boiler house was proposed;

in the versions of the AST the installed capacity of the peak-load boilers was taken with allowance made for the reserve, which is equal to the capacity of one reactor.

The curves of the change of the maximum specific capital investments in an AST depending on the estimated heat load of the region with a different cost of organic fuel are presented in Figure 2.

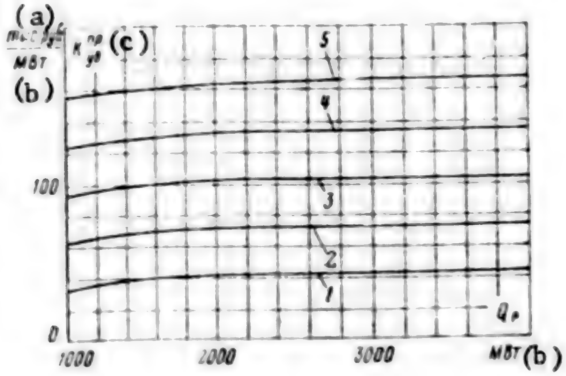

Figure 2. Diagram of the Dependence of the Change of the Maximum Specific Capital Investments in an AST on the Estimated Heat Load of the Region and the Cost of Organic Fuel

1-5--the cost of organic fuel respectively of 20, 30, 40, 50 and 60 rubles per ton of conventional fuel

Key:

a. Thousands of rubles
b. MW
c. Maximum specific capital investments

The analysis of these data shows that with an increase of the heat load of a region the maximum specific capital investments in the AST increase negligibly. The cost of organic fuel, with the increase of which from 20 to 60 rubles/ton of conventional fuel the indicated indicator increase four- to fivefold, has the main influence on the change of the maximum specific capital investments.

The efficiency and reliability of operation of an AST to a considerable extent depend on the selection of the most efficient conditions of its operation jointly with the peak-load boiler houses, which will be located, as a rule, at the center of the heat loads. In this case two possible arrangements of the connection of the AST and the peak-load boiler house: series and parallel, can be put into effect. The examination of these arrangements and the analysis of the variable conditions of the joint operation of the AST and the peak-load boiler during the heating period showed that the parallel arrangement, which is depicted in Figure 3, is the most efficient.

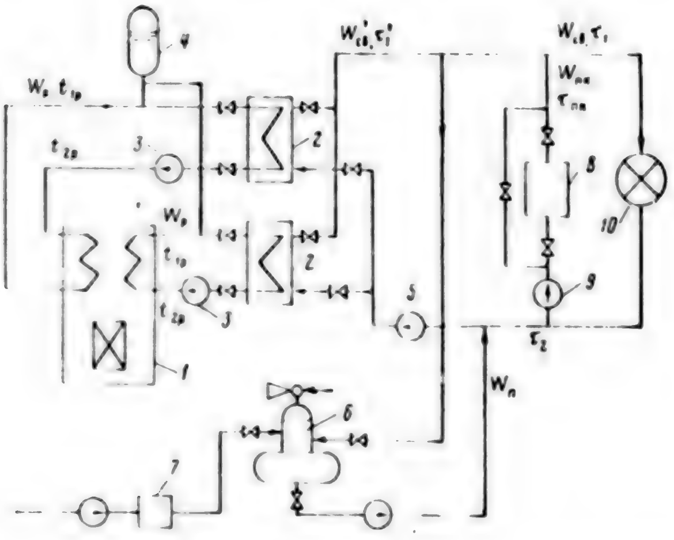

Figure 3. Schematic Diagram of Heat Supply With the Parallel Connection of the AST and the Peak-Load Boiler

1--reactor of the AST; 2--heaters of the network water of the AST; 3--pumps of the intermediate loop of the AST; 4--pressurizer; 5--pump of network water; 6--vacuum deaerator of the water-level maintenance of the heating network; 7--chemical water treatment of the heating network; 8--peak-load boiler house; 9--pumps of the peak-load boiler house; 10--heat user

The curves of the change in the average daily values of the temperature and consumption of water during the year at different points of the heat supply system with the parallel connection of the AST and the peak-load boiler house depending on the relative heat load of the region are constructed in

Figure 4. The main peculiarity of the parallel arrangement is that the amount of heated network water in the AST and the peak-load boiler house is determined by the adopted coefficient $\alpha_{AST}$. In the case in question $\alpha_{AST} = 0.5$, as a result of which the consumption of network water through the network heaters of the AST is 50 percent of the total water consumption in the city network.

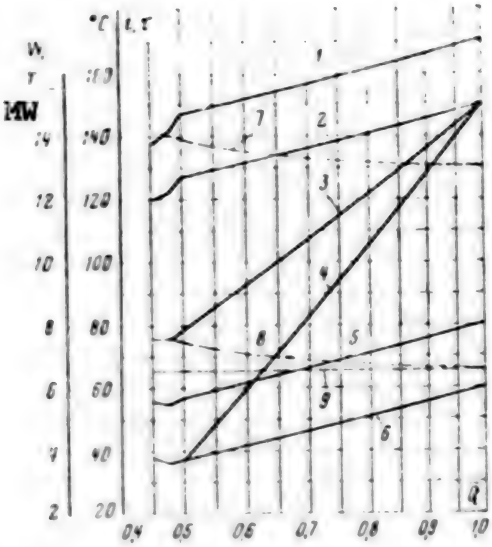

Figure 4. Diagram of the Change in the Average Daily Values of the Temperature and Consumption of Water With the Parallel Connection of the AST and the Peak-Load Boiler House ($\alpha_{AST} = 0.5$)

1, 5--water temperature respectively when leaving the reactor $t_{1p}$ and entering the reactor $t_{2p}$; 2, 3, 4--temperature of the network water respectively after the AST $\tau'_1$, in the city network $\tau_1$, after the peak-load boiler house $\tau_{ПК}$; 6--temperature of the return network water $\tau_2$; 7, 8--specific consumption of network water respectively in the city network $W_{CB}$ and through the peak-load boiler house $W_{ПК}$; 9--specific consumption of water through the reactor and of network water after the AST $W_{П}$, $W'_{CB}$

It was assumed that the heat load of the reactors of the AST during the period of operation of the peak-load boilers (approximately 3,500 hr for the conditions of the central regions) remains constant. The average daily consumptions of water in the intermediate loop of the AST and of network water, which is heated in the network heaters, were taken to be identical and remain constant during the entire heating period. The consumption of network water, which passes through the peak-load boiler house, during the heating season changes slightly due to the change in the hydraulic resistance of installations of the subscribers and does not require special regulation at the pumps of the boiler house.

The temperature of the network water on entering the network heaters fluctuates in conformity with the curve of the change in temperature of the return network water from 60°C under reference conditions to 37°C at the end of the heating period. The water temperature on leaving these heaters ranges respectively from 150 to 119°C.

To ensure the required temperature curve in the city network the water temperature after the peak-load boiler house ranges from 150°C under the reference conditions to 37°C when the boiler house is disconnected. Under the conditions with the least temperature loads the return network water is added to the water arriving from the AST without heating at the boiler house.

Thus, the analysis which has been made shows that with the joint operation of the AST and the peak-load boiler house the possibility exists to provide sufficiently favorable average daily operating conditions of the reactor plants of the AST. In particular, the consumption of water in the intermediate loop remains constant during the entire heating period, while its temperature changes by only 30°C.

Estimates show that the possibility exists to keep the average daily temperatures of the water when entering and leaving the reactor constant under all the necessary conditions. However, in this case the need arises to regulate over a quite wide range the consumptions of the network water which is heated in the heaters of the AST and the peak-load boiler house.

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ELECTRIC POWER AND POWER EQUIPMENT

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# DEVELOPMENT OF HEAT, ELECTRIC POWER STATIONS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 11, Nov 79 pp 16-22

/Article by engineers V. P. Korytnikov, M. I. Gitman, Candidate of Technical Sciences Ya. A. Kovylyanskiy and engineer I. A. Smirnov, All-Union Scientific Research Planning Institute of Power Systems and Electric Power Networks: "The Development of Heat and Electric Power Stations at the New Stage"*/

/Text/ As is known, the Soviet Union holds first place in the world in the development of central heating, which ensures on a national scale a considerable saving of fuel. The concentration of heat loads, which results from the increase of the sizes of residential settlements with a dense multistory housing system, the creation of major industrial complexes and the formation on the basis of this of entire housing and industrial agglomerations, is objectively conducive to the further development of central heating /1, 2/.

For a considerable period of time heat and electric power stations (TETs's) operated primarily during the base part of the curve of the electric power loads, and the change of their electric capacity on the daily curve on the average did not exceed 15 percent /3-5/. Such conditions of the use of the electric capacity of TETs's ensure the maximum generation of electric power on heat consumption with the minimum specific consumptions of fuel. However, in the power systems of the European part of the country the rise in the variable part of the curve of the electric power loads and the increase of the proportion of poorly maneuverable base power blocks (which operate at supercritical steam parameters) led to the need to alter the condition of the use of the electric capacity of TETs's.

Back in 1974 Academician L. A. Melent'yev expressed the idea about the need to have highly maneuverable TETs's with their thorough discharge during the minimum electric power loads /6/. Later the works of the All-Union

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[*] For purposes of discussion--editor.

Scientific Research Planning Institute of Power Systems and Electric Power Networks /7, 8/ showed: if the discharging of a TETs during the minimum will make it possible in place of semipeak condensing blocks /9/ to introduce condensing base blocks powered by organic fuel, the economically permissible duration of the forced discharging of the takeoffs of the turbines for the purpose of reducing their electric capacity during the minimum will be about 1,000 hr a year, which will make it possible to increase the range of the change in capacity of the TETs on the daily curve to 20-25 percent. Here, in spite of the loss of cogeneration, in the power system as a whole a saving of fuel will be ensured.

Under present conditions it should be assumed that in the European part of the country, with allowance made for the considerable increase anticipated in the future in the cost of organic fuel, the increase of the base capacities in the next few years will be obtained by the construction of nuclear electric power stations (inclduing nuclear TETs's). Under these conditions the efficiency of the development of central heating using organic fuel on the basis of classical TETs's, which operate during the base part of the curve of the electric power loads, objectively decreases. Along with this in the European part of the country the problem of covering the variable part of the curves of the electric power loads is becoming more and more urgent, in connection with which the economically expedient scale of the involvement of TETs's in work in the mode of variable capacity is increasing.

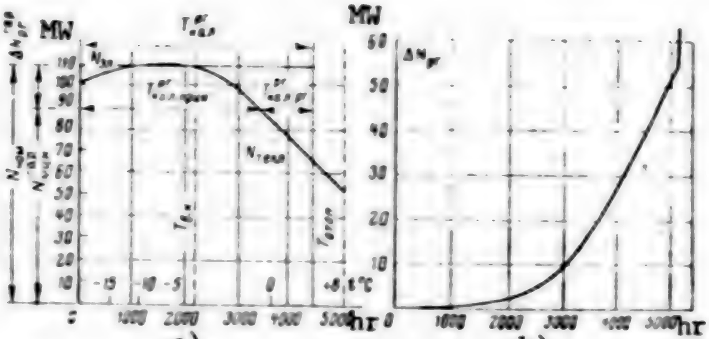
It is known that in the power systems with the greatest irregularity of the daily curve of the electric power loads the extent of the night drop of the loads reaches 45-50 percent of the maximum /5/, and 10-15 percent falls to the peak part of the curve, which is covered by hydroelectric power stations and by thermal electric power stations, which operate under peak conditions. Thus, the extent of the discharge during the minimum with respect to the daily semipeak load will be 30-35 percent, which determines the necessary scale of the semipeak capacity.

At present and in the next few years more than half of this amount can be provided by the discharging of condensing base blocks powered by organic fuel (within the limits of the permissible extent of the discharging of the boilers on the condition of their steady operation). Here the proportion of the other necessary sources of the semipeak capacity will be about 15 percent of the total load of the unified power system.

Among such sources, along with the possible discharging of TETs's, are: version 1--semipeak condensing blocks powered by solid fuel; version 2--nuclear electric power stations, which operation under semipeak conditions /5, 10, 11/; version 3--pumped-storage electric power stations, which are charged from TETs's.

The data of the calculations for determining the relative degree of economy of the discharging of TETs's during the minimum electric power loads in comparison with the enumerated versions for obtaining the semipeak capacity in the unified power system are cited below. When determining the indicators of maneuverable TETs's with their discharge during the minimum it was taken into account:

owing to the known dependence of the capacity of TETs's operating on heat consumption on the outdoor temperature the duration of the forced discharging according to the heat increases as the extent of discharging increases (Figure 1);



a) b)

Figure 1. Curves of the Forced Discharging of TETs's According to the Heat

a--the change in the capacity of the turbine of a TETs (using the example of the T-100 turbine of the Unified Power System of the Center); $N_{тепл}$ is the heat consumption capacity (during the hours of the minimum heat loads); $N_{ном}$ is the nominal capacity, which is taken into account in the balance of the power system (regardless of the hours of the minimum); $N^{гар}_{мин}$ is the guaranteed minimum capacity during the hours of the minimum electric power loads; $\Delta N^{гар}_{мин}$ is the guaranteed (estimated) decrease of the capacity during the minimum (the discharge); $T^{рг}_{кал}$ is the calendar duration of the period of discharging during the minimum; $T^{рг}_{кал.прин}$ is the calendar duration of the period of the forced discharge of the takeoffs; $T^{рг}_{кал.рг}$ is the calendar duration of the period of the "natural" (condensation) discharge; $T_{отоп}$ is the heating period; $T_{в.к}$ is the period of operation of the hot water boilers; b--the dependence of the calendar period of the forced discharging of the takeoffs on the extent of the reduction of the electric capacity during the minimum electric power loads.

bearing in mind that the discharging of the TETs is carried out at night and on days off, the actual time of discharging $T^{рг}_{факт}$ is 45 percent of the calendar duration of the period $T^{рг}_{кал}$, during which such discharging is carried out /7/;

the calculations according to versions 1 and 2 of the coverage of the semipeak capacity were made for the period of the forced discharging of the TETs according to the heat, which is connected with the loss of cogeneration, on the assumption that the discharging according to the condensation capacity of the TETs's during the periods of their small heat load is also used in the version of the unmaneuverable TETs's, instead of the discharging of the base blocks of condensation electric power stations.

For completeness of the picture the following basic premises were examined when evaluating the effectiveness of the reduction of the electric capacity of TETs's during the minimum electric power loads as compared with semipeak condensation electric power stations.

1. The capacity of nuclear electric power stations is not limited and in the European part of the country the generation of electric power in the base part of the curve is completed by them. In this case base nuclear electric power stations are being built to the extent of the supplanting of TETs's from this part of the curve, while in the version of the refusal to use the maneuverability of TETs's semipeak condensing blocks are being built. The consumption and transportation of organic fuel per kW of semipeak capacity of the power system in the version of maneuverable TETs's are reduced to approximately one-third as compared with the version of semipeak condensation electric power stations (the elimination of semipeak blocks at condensation electric power stations and the reduction of fuel consumption at TETs's).

2. The capacity of nuclear electric power stations for the country as a whole is set identically. In this case in the version of the use of the maneuverable qualities of TETs's all the nuclear electric power stations are being built as base power stations and are being located in the European part of the country. When the use of the maneuverable properties of TETs's is rejected, the need arises to built semipeak condensing blocks, which displace a portion of the nuclear electric power stations to the eastern regions of the country. These nuclear electric power stations in turn replace the base condensation electric power stations, the fuel of which is sent to the semipeak blocks in the European part of the country.

The consumption of organic fuel in both versions is approximately the same, but in the version of the discharging of TETs's the need is eliminated to transport fuel to the European part in the amount of approximately 2 tons (in physical terms) per kW of discharge (as a result of the reduction of the number of hours of use of the TETs's and the elimination of semipeak condensation electric power stations).

Further in the calculations according to version 1 it was assumed: the specific capital investments $K_{б} = 150$ rubles/kW, $K_{пп} = 137$ rubles/kW (blocks with K-500-130 turbines); the capital investments for ensuring the discharge of the TETs during the minimum $K^{pr}_{тэц} = 20$ rubles/kW--in the greatest amount according to [7]; the specific consumptions of conventional fuel--$b_{б} = 331$ g/kWh, $b_{пп} = 383$ g/kWh, $b^{тепл}_{тэц} = 170$ g/kWh; the inclusive expenditures on conventional solid fuel in the European part $3^{T}_{евр} = 35$ rubles/ton, the same in Siberia--18 rubles/ton; the inclusive expenditures on the electric power of nuclear electric power stations $3^{э}_{a} = 13-14$ rubles/kWh, including the fuel component of 3-4 rubles/kWh; the number of hours of use--$T_{б} = 6{,}000$ hr/year, $T_{пп} = 3{,}500$ hr/year, $T_{a} = 6{,}500$ hr/year.

The calculations showed that with the indicated initial data and any practically possible duration of the period of the forced discharging for heat during the hours of the minimum electric power loads, which to an extent is confined to the duration of the heating period, such a discharging is more economical than the use of semipeak blocks. For the conditions of the Unified Power System of the Center, given $T_{\text{отоп}} = 5,100$ hr and correspondingly $T^{pr}_{\text{факт}} = 2,300$ hr, the correlation of the adjusted expenditures according to the versions per kW of semipeak capacity is shown in Table 1.

Table 1

| Version | Adjusted expenditures by versions, rubles/kW | | Overexpenditure according to the version of semipeak blocks, percent |
|---|---|---|---|
| | Discharging of TETs | Semipeak blocks | |
| Semipeak power blocks which replace nuclear electric power stations. . . . . . . . . . . . | 88-95* | 101 | 15-6* |
| Semipeak power blocks, which displace nuclear electric power stations from the European part to the eastern regions of the country. . . . . . | 74 | 95 | 27 |

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* Over the range of the change of the fuel component of the electric power of nuclear electric power stations.

The amount of the inclusive expenditures on conventional fuel in the European part of the country, which is equal in the examined version to 24-30 rubles/ton, which is considerably less than the price for fuel, which can be expected here in the future, corresponds to the conditions of the different degree of economy of the versions of the forced discharging of TETs's during the entire indicated period and the use of semipeak blocks.

In the calculation according to version 2 (the discharging of nuclear electric power stations) the following values of the initial cost and operating indicators were examined: the inclusive expenditures on conventional organic fuel (coal) at TETs's $З^{т}$ are 27, 30, 35 and 40 rubles/ton; the fuel component of the inclusive expenditures on the electric power of nuclear electric power stations $И^{т}_{а}$ is 3, 4 and 5 rubles/MWh; the duration of the forced discharging of the TETs's for heat (and correspondingly the discharging of nuclear electric power stations)--the calendar duration $T^{pr}_{\text{кал}}$: 6,500, 5,000, 3,500 and 2,000 hr, the actual duration $T^{pr}_{\text{факт}}$: 2,900, 2,200, 1,600 and 900 hr.

Unlike the preceding version, the degree of economy of the discharging of TETs's as compared with the discharging of nuclear electric power stations increases as the calendar duration of the discharging increases, since here a greater saving of organic fuel is ensured.

The maximum permissible capital investments for the purpose of ensuring the discharging of TETs's during the minimum electric power loads $K^{pr}_{ТЭЦ}$, in case of which such a discharging is just as economical as the discharging of nuclear electric power stations, were determined for the indicated values of the initial data. The results of the calculation are presented in Figure 2.

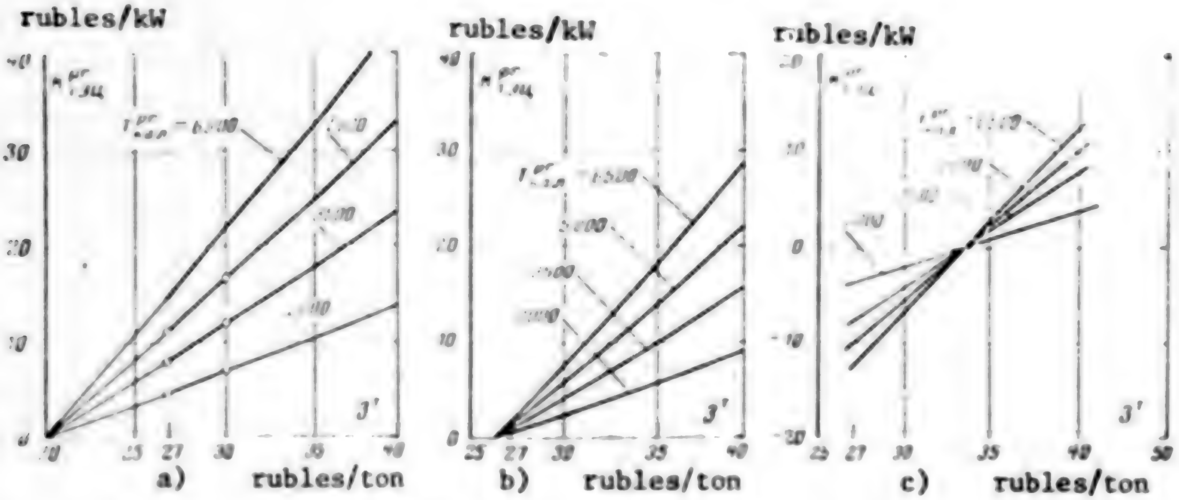


Figure 2. Diagrams of the Maximum Permissible Capital Expenditures at a TETs for Ensuring Its Discharging During the Minimum Electric Power Loads (in Comparison With the Discharging of a Nuclear Electric Power Station)

a, b, c--with a fuel component of the inclusive expenditures on the electric power of nuclear electric power stations respectively of 3, 4 and 5 rubles per MWh

When analyzing the obtained results it is necessary to bear in mind the following:

the value $T^{pr}_{кап} = 2{,}000$ hr corresponds to the discharge, which does not require the installation of additional equipment at the TETs, but the extent of the discharge here is small (from 5-8 percent for electric power stations which are completely charged on heat, up to 30-35 percent for electric power stations which operate under the conditions of the accumulation of heat loads) and does not characterize the total possibilities of utilizing the maneuverability of the TETs;

the value $T^{pr}_{кап} = 3{,}500$ hr corresponds to the duration of the period of discharging, which is approximately equal to the period of operation of the hot water boilers (given $\alpha_T = 0.5$), here the extent of discharging during the minimum reaches a considerably greater value (respectively 20 and 50 percent and on the average for all categories of electric power stations

25-30 percent) and, as a rule, also does not require the installation of additional equipment at the TETs;

the value $T^{pr}_{кап} = 5,000$ hr corresponds to the duration of the heating period and in practice means the possibility of completely halting the turbines of the TETs during the minimum electric power loads during this period;

the value $T^{pr}_{кап} = 6,500$ hr characterizes the discharging of the TETs during the minimum for the entire year, which is usually not required, therefore it is impossible to use the corresponding value $T^{pr}_{тэц}$, which in this case is the greatest.

The dependences of $K^{pr}_{тэц}$ given $T^{pr}_{кап} = 3,500$ hr, which corresponds to the partial discharging of the TETs during the minimum electric power loads, and given $T^{pr}_{кап} = 5,000$ hr, which applies to the possibility of shutting it down, are of practical interest. With the complete shutdown of the turbines of the TETs during the minimum electric power loads the maximum permissible additional capital investments at the TETs increase as compared with the case $T^{pr}_{кап} = 3,500$ hr approximately 1.5-fold.

The relative efficiency of the discharging of a TETs during the minimum as compared with the discharging of a nuclear electric power station decreases as the cost of nuclear fuel increases, but if we rule out the practically improbable combination of a very low cost of conventional organic fuel ($З^т \leq 30$ rubles/ton) and a very high cost of nuclear fuel ($Ц^т{}_a = 5$ rubles/MWh), the values of $K^{pr}_{кап}$ are always positive, that is, additional capital investments, which increase as the extent of discharging increases, are permissible for ensuring the discharging of the TETs during the minimum. For example, given $Ц^т{}_a = 3$ rubles/MWh and $З^т = 30$-$35$ rubles/ton the value of the permissible capital investments at a TETs will be 12-18 rubles/kW with partial discharging and 17-25 rubles/kW with a shutdown; in a similar manner, given $Ц^т{}_a = 4$ rubles/MWh and $З^т = 35$-$40$ rubles/ton it will be respectively 10-16 and 14-22 rubles/kW.

If it is considered that the installation of additional pressure-reducing and cooling units and peak-load heaters of the network water is necessary for ensuring the thorough discharging of heating TETs's, their cost depending on local conditions can be estimated in the amount of 4,000-8,000 rubles per gigacalorie, or given an initial pressure of the TETs of 130 kgf/cm$^2$ in the amount of 8-15 rubles/kW, that is, within the range of what is permissible. The necessary additional capital investments for ensuring the discharge of industrial takeoffs will be even less.

From the cited data it follows that as compared with the examined versions any thorough discharging of a TETs during the minimum for the entire heating period is economically advisable. To an extent it is possible to speak of the complete shutdown of the turbines of a TETs during the minimum (on the conditions of the safekeeping of the equipment the motor mode, which was proposed by the All-Union Institute of Heat Engineering imeni F. E.

Dzerzhinskiy, can be used instead of shutting down the turbines), since in contrast to condensation electric power stations technical restrictions, which are connected with the discharging of the boilers, are in effect here to a lesser extent, since the loading of the heat users (through the pressure-reducing and cooling units) is maintained at them. The expenditures of heat on the start-ups and shutdowns of the turbines to a considerable extent can be utilized in the heat circuit of the TETs and therefore in practice will not influence the indicators of the version of the discharging of the TETs.

When comparing the discharging of TETs's during the minimum with the construction of pumped-storage electric power stations, which are charged from TETs's, since this charging takes place only at night, the discharging of the TETs's should be considered only during night hours (during days off the possibility of the additional shutdown of the base blocks powered by organic fuel is taken into account in both versions). Since the pumped-storage electric power station provides an additional peak-load capacity, the construction at TETs's of peak-load gas turbine power plants of the same capacity with the use of the heat of the exhaust for replacing the loads of the takeoffs or the high-pressure heaters is taken into account in the version of the maneuverability of TETs's /12/.

In the calculations the following indicators of the pumped-storage electric power station were used: the specific capital investments $K_{\text{уд}} = 170$ rubles per kW (according to the capacity in the turbine mode); $N_{\text{нас}} = 1.2\ N_{\text{турб}}$, where $N_{\text{нас}}$ and $N_{\text{турб}}$ are the capacities of the pumped-storage electric power station respectively in the pump and turbine modes; the total efficiency of the plant $\eta_{\Sigma} = 0.7$; the duration of the turbine mode $T_{\text{турб}} = 4$ hr/day with 100, 150 and 200 days of operation of the pumped-storage electric power station a year ($T_{\text{ГАЭС}}$); $И_{\text{пост}} = 2.3$ percent K ($З_{\text{пост}} = 0.143$ K), where $И_{\text{пост}}$ is the fixed portion of the costs as a percentage of the capital investments; $З_{\text{пост}}$ is the fixed portion of the adjusted expenditures with allowance made for the standard coefficient of efficiency.

The capital investments for the purpose of ensuring the discharging of the TETs during the minimum were examined over the range of 0-15 rubles/kW, the capital investments in peak-load gas turbine power plants--in the amount of 72 rubles/kW (with allowance made for the increase of the capacity of the steam turbine during the operation of the gas turbine power plants); the specific consumptions of fuel of the gas turbine power plants depending on their arrangement--over the interval of 320-400 g/kWh; $И_{\text{пост}} = 13$ percent K ($З_{\text{пост}} = 0.25$ K).

The relative increases of the specific consumptions of fuel at gas and fuel oil TETs's and coal TETs's when charging the pumped-storage electric power stations are: in the central heating mode 145-150 g/kWh, in the condensation mode 300-310 g/kWh; the inclusive expenditures on conventional fuel for coal TETs's--35 rubles/ton, gas and fuel oil TETs's (80 percent gas)--45 rubles/ton, gas turbine power plants (gas)--42 rubles/ton.

The correlation of the adjusted expenditures by versions per kW of peak capacity (which corresponds to 1.2 kW of the discharge of TETs's during the minimum) given the assumed values of the initial amounts is shown in Figure 3. It is apparent that under average conditions ($K^{\text{пг}}_{\text{тэц}} = 7$ rubles/kW; $b_{\text{гту}} = 360$ g/kWh; $T_{\text{ГАЭС}} = 150$ days) and with the charging of the pumped-storage electric power station, which is carried out only by means of the central heat generation of the TETs, the discharging of the TETs at night is more economical than the version of the pumped-storage electric power station (by 2 percent in the case of coal TETs's and by 5 percent in the case of gas and fuel oil TETs's). This means that under the indicated average conditions the degree of discharging of the TETs at night (up to the shutdown of the turbines) in combination with gas turbine power plants is more efficient than the use of the pumped-storage electric power station.

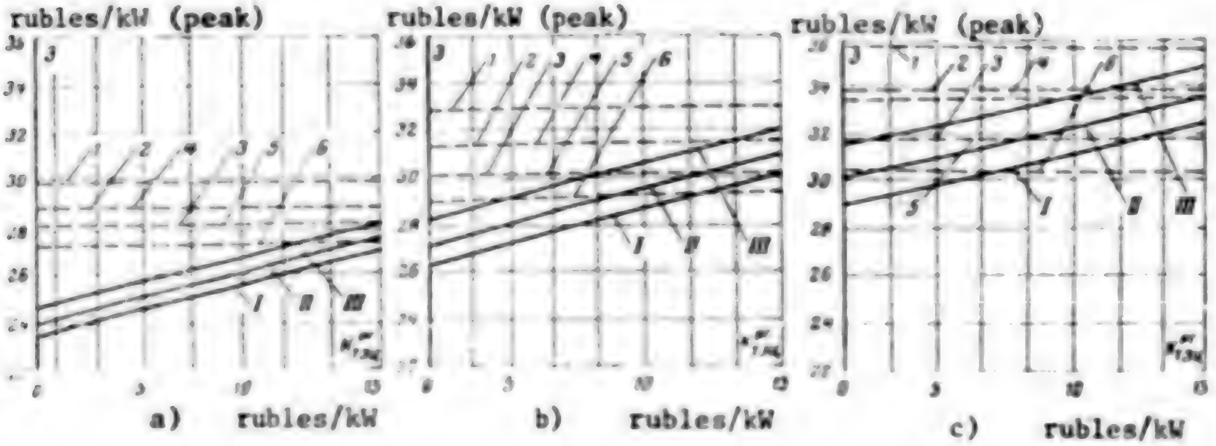


Figure 3. Diagrams of the Adjusted Expenditures per kW of Peak Capacity in the Versions of Maneuverable TETs's and Pumped-Storage Electric Power Stations, Which Are Charged From TETs's (for the Unified Power System of the Center)

a, b, c--with the number of days of operation of the pumped-storage electric power station during the year respectively of 100, 150 and 200; the solid lines are the discharging of the TETs and the gas turbine power plants, the broken lines are the pumped-storage electric power station with charging from the TETs; I, II and III--with the specific consumption of fuel of the gas turbine power plants respectively of 320, 360 and 400 g/kWh; 1, 2, 3--with the charging of the pumped-storage electric power station from gas and fuel oil TETs's with specific consumptions of fuel respectively of 222, 184 and 145 g/kWh; 4, 5, 6--with the charging of the pumped-storage electric power station from coal TETs's with specific consumptions of fuel respectively of 230, 190 and 150 g/kWh; the proportions of cogeneration in the power going for the charging of the pumped-storage electric power station for 1, 2, 3 and 4, 5, 6 are respectively 50, 75 and 100 percent.

Under the most unfavorable conditions ($K^{pr}_{\text{ТЭЦ}} = 10$ rubles/kW, $b_{\text{ГТУ}} = 400$ g/kWh, $T_{\text{ГАЭС}} = 200$ days) the discharging of the TETs during the minimum, as the calculations showed, is advisable in the amount of 40-50 percent.

On the whole it can be established that if the condensation generation of the TETs is used in part for the charging of the pumped-storage electric power station, which corresponds to its incomplete discharging during the minimum, while the duration of operation of the pumped-storage electric power station does not exceed 150 days a year, the use of the maneuverability of the TETs in all cases is more economical than the use of the pumped-storage electric power station. If during the thorough discharging of the TETs during the minimum and especially a shutdown the entire charging of the pumped-storage electric power station is accomplished by central heat generation, while the duration of the operation of the pumped-storage electric power station exceeds 150 days a year, under certain conditions the version of the pumped-storage electric power station can become more efficient than the version of maneuverable TETs's.

For operating TETs's without their renovation in practice the possible scale of the reduction of the electric capacity during the minimum electric power loads can be determined on the basis of the surplus capacity of the peak-load sources of heat and the pressure-reducing and cooling units at the design temperature. The calculations made for a large number of operating TETs's, which are 80-100 percent charged for heat, showed that on the average their capacity during the minimum electric power loads can be reduced by approximately 30-35 percent (with considerable fluctuations of the extent and duration of forced discharging for some electric power stations depending on their loading for heat and the composition of the equipment) /13/.

The presented data concern the evaluation of the possible scale of the maneuverability of TETs's (operating, under construction, being planned), which was already taken into account in the balance of the generating capacities of the power systems. However, the views are being stated that, since the TETs's present in the power systems can operate with thorough discharging during the minimum, this eliminates the problem of providing a semipeak capacity for a number of years, while the construction of new TETs's under present conditions is ostensibly becoming less economical.

It should be borne in mind that a considerable period (up to 10 years) passed from the start of the planning of a TETs until its placement into operation, while plans, which have been drafted, but not implemented in time, gradually become obsolete. As a result the tendency for the scale of central heating to decrease a number of years after the exhaustion of of the potentials of the maneuverability of operating TETs's can again lead to a shortage of semipeak capacity in the power systems, and the moment for providing it will be passed.

Comparative estimates of the combined and separate schemes of power supply as applied to a heat load of 1,500 gigacalories/hr (this and a greater concentration of the loads, according to [2], is typical of the users, the proportion of which is more than 60 percent of all the heat loads of the cities and industry of the country) were made in order to evaluate the advisability of using central heating under these conditions. The construction of semipeak TETs's with the complete shutdown of the turbine during minimum electric power loads ($T_{\text{пп}} = 3{,}500$ hr/year) according to two versions: the coal-powered steam turbine TETs--3 X T-175 and the steam and gas TETs with the use of the heat of the exhaust of the gas turbine power plant in the system of the regenerative heating of drinking water (the disconnection of the high-pressure heater)--3X T-175 + GT-45--was examined in these estimates for the combined scheme.

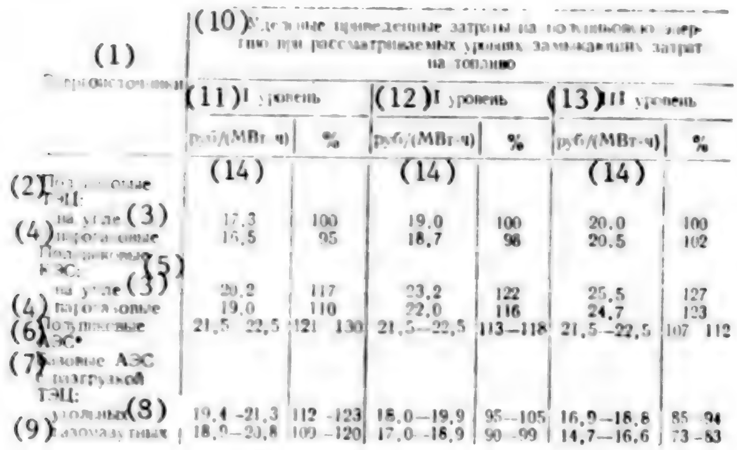
For the separate scheme we examined the construction of regional boiler houses and the following versions of the introduction of the semipeak capacity: the already examined semipeak coal-powered condensation electric power stations; semipeak steam and gas condensation electric power stations (K-500-130 + GT-100 blocks according to an arrangement similar to the steam and gas TETs); nuclear electric power stations which operate under semipeak conditions. The construction of nuclear electric power stations in combination with the discharging of the existing TETs's powered by coal and by gas with fuel oil (in conformity with the conditions of the operation of the semipeak blocks) was also examined.

In addition to the cited data in the estimates we took the specific capital investments: in semipeak steam turbine and gas and steam TETs's--$K_{\text{пп}}^{\text{ТЭЦпт}} = 221$ rubles/kW and $K_{\text{пг}}^{\text{ТЭЦпг}} = 178$ rubles/kW, in semipeak steam and gas condensation electric power stations and in boiler houses--$K_{\text{пп}}^{\text{пг}} = 127$ rubles/kW and $K_{\text{кот}}^{\text{уг}} = 23{,}000$ rubles/(gigacalorie/hr); correspondingly the specific consumptions of fuel: $b_{\text{пп}}^{\text{ТЭЦпп}} \doteq 230$ g/kWh was used according to the average indicators of conventional TETs's as applied to 70 percent of the central heating generation and 30 percent of the condensation generation; $b_{\text{пп}}^{\text{ТЭЦпг}} = 262$ g/kWh, $b_{\text{пп}}^{\text{пг}} = 354$ g/kWh--including two-thirds coal and one-third gas. In the versions of the discharge of operating TETs's the relative increase of the specific consumptions of fuel on the lost generation of the TETs's was taken in the amount of 200-205 g/kWh, which corresponds to two-thirds of the central heating generation and one-third of the condensation generation.

The inclusive expenditures on conventional fuel were examined for three levels: 27, 30 and 41 rubles/ton for coal, 30, 40 and 50 rubles/ton for gas and 31, 43 and 60 rubles/tons for fuel oil. The expenditures on the electric power of nuclear electric power plants were taken for all the levels in the previously indicated amount--13-14 rubles/MWh for $T_a = 6{,}500$ hr.

The final data of the calculations are presented in Table 2. Over the entire range of the change in the inclusive expenditures on organic fuel the maneuverable TETs's are the most economical source of the semipeak capacity in power systems. With low inclusive expenditures for fuel the construction of new maneuverable TETs's is more economical, with high inclusive expenditures for fuel the priority discharging of operating TETs's with the construction of nuclear electric power stations is advisable. With an average level (coal at 35 rubles/ton, gas at 40 rubles/ton) both versions are approximately equal and are 15-20 percent more economical than the versions of semipeak condensation electric power stations and nuclear electric power stations.

Table 2



| (1) Энергоисточники | (10) Удельные приведенные затраты на полупиковую энергию при рассматриваемых уровнях замыкающих затрат на топливо | | | | | |
|---|---|---|---|---|---|---|
| | (11) I уровень | | (12) I уровень | | (13) II уровень | |
| | руб/(МВт·ч) (14) | % | руб/(МВт·ч) (14) | % | руб/(МВт·ч) (14) | % |
| (2) Полупиковые ТЭЦ: | | | | | | |
| на угле (3) | 17,3 | 100 | 19,0 | 100 | 20,0 | 100 |
| (4) парогазовые | 16,5 | 95 | 18,7 | 98 | 20,5 | 102 |
| Полупиковые КЭС: (5) | | | | | | |
| на угле (3) | 20,2 | 117 | 23,2 | 122 | 25,5 | 127 |
| (4) парогазовые | 19,0 | 110 | 22,0 | 116 | 24,7 | 123 |
| (6) Полупиковые АЭС* | 21,5—22,5 | 121—130 | 21,5—22,5 | 113—118 | 21,5—22,5 | 107—112 |
| (7) Базовые АЭС с разгрузкой ТЭЦ: | | | | | | |
| угольных (8) | 19,4—21,3 | 112—123 | 18,0—19,9 | 95—105 | 16,9—18,8 | 85—94 |
| (9) газомазутных | 18,9—20,8 | 109—120 | 17,0—18,9 | 90—99 | 14,7—16,6 | 73—83 |

Key:

1. Power sources
2. Semipeak TETs's
3. Coal-powered
4. Steam and gas
5. Semipeak condensation electric power stations
6. Semipeak nuclear electric power stations*
7. Base nuclear electric power stations with the discharging of TETs's
8. Coal
9. Gas and fuel oil
10. Specific adjusted expenditures on semipeak power with the levels in question of the inclusive expenditures on fuel
11. Level I
12. Level II
13. Level III
14. Rubles/MWh

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* Over the range of the change in the fuel component of the electric power of nuclear electric power stations.

The discharging of operating gas and fuel oil TETs's is more economical than coal TETs's. For new semipeak coal-powered TETs's and steam and gas TETs's the indicators are approximately the same, but with an increase of the inclusive expenditures for fuel the advantage shifts to coal TETs's.

Thus, when solving the question of building new electric power stations the advantage of the combined scheme of power supply, which is accomplished by the construction of maneuverable TETs's, is fully maintained. During the specific designing of such electric power stations solutions, which increase the degree of their economy both by means of the reduction of the cost of construction and by means of the decrease of the losses of cogeneration, should and can be found.

In all cases the operating conditions of such TETs's with a breakdown by years should not correspond precisely to the designed operating conditions of the semipeak blocks of condensation electric power stations. Thus, whereas during the nonheating period the semipeak blocks should be shut down during the minimum electric power loads, but during the remaining hours are not used at full capacity, while at the most economical operating TETs's the partial recharging with the condensation capacity is maintained /14/, the semipeak TETs's during this period can operate all or a portion of the units on heat consumption with the corresponding reduction of the condensation capacity of the operating TETs's.

During the operating process other cases of the maintenance at semipeak TETs's of central heating generation during the minimum electric power loads (for example, when a nuclear electric power station is taken out of service for repair) are also possible, which will lessen the demands on the equipment of these TETs's and increase their degree of economy.

Moreover, the construction not of purely semipeak TETs's with their complete shutdown at night and on days off, but of completely maneuverable (base-maneuverable) TETs's, which are discharged during the minimum to 20-30 percent of their electric capacity, may become the optimum.

With a sufficiently high proportion of TETs's in the Unified Power Systems of the Center, the Northwest, the Urals and the Middle Volga the thorough discharging of TETs's during the minimum in practice can solve the problem of overcoming the minimum electric power loads in these unified power systems, and with allowance made for the reverse overcurrents of the capacity between unified power systems, also in the Unified Power System of the South. Thus, whereas the proportion of TETs's in the power systems is equal to approximately 30 percent, which on the whole is proper for the European part of the country, while the overall shortage of semipeak capacity, which is not met by the discharging of condensation electric power stations powered by organic fuel, is, as was indicated earlier, about 15 percent of the total loads of the unified power systems, the necessary scale of maneuverability can be ensured if all the TETs's are discharged during the minimum on the average by 40-50 percent, which in many cases, according to /13/, can be accomplished with their operating equipment. For some electric power stations this amount should be differentiated depending on the loading for heat and the composition of the equipment. With the least loss of the degree of economy the greatest reduction of the capacity of TETs's during the minimum electric power loads can be achieved at electric power stations which are underload for heat /8/.

In the future, when the capacity of nuclear electric power stations in the European part of the country, according to /5/, reaches 25 percent, while the operating blocks powered by organic fuel can be discharged within the limits of the existing norms /5/, with the maintenance in the power systems of a proportion of TETs's, which is equal to 30-35 percent, their discharging by 65-70 percent will ensure the passage of the minimum in the power systems without a reduction of the load of nuclear electric power stations.

Here it is incorrect to assume that the use of such a scale of maneuverability of TETs's will significantly decrease the efficiency of central heating: indeed, since the discharging of TETs's during the minimum is accompanied by the loss in part of cogeneration and in part of condensation generation, the proportion of cogeneration of TETs's depending on the extent of discharging may change slightly. However, the main harm from the use of the maneuverability of TETs's will consist in the decrease of the amount of cogeneration and correspondingly an increase of the specific consumptions of fuel for the power system as a whole. But the decrease of the proportion of TETs's in the power systems with a simultaneous loss of maneuverable capacity at them will lead to the same result.

Of course, the accomplishment of the thorough discharging of TETs's during the minimum should be preceded by the renovation of their heating circuit with the installation of additional equipment, while for new TETs's such conditions should be taken into account during their designing. At present work on ensuring the maneuverability of the existing equipment of TETs's is being carried out by Soyuztekhenergo, the All-Union Institute of Heat Engineering imeni F. E. Dzerzhinskiy, the Moscow Regional Administration of Power System Management and other organizations. The rates of change of the temperature, which are permissible in the process of cooling, given its different absolute values have been determined for turbines. Rational conditions of the start-ups of T-50/60-130, T-100/120-130, T-250/300-240 and PT-50/60-130 turbines are being worked out, tests of the start-up conditions of the PT-135-130 turbine are being conducted. Work is being carried out on the conversion to turbines to the steamless (motor) mode, which, according to the data of the All-Union Institute of Heat Engineering imeni F. E. Dzerzhinskiy, with the need to discharge for 6-8 hr is more economical than a thorough (to 5-10 percent) discharge or shutdown. For the T-100/120-130 turbine instructions on start-ups and shutdowns with the shortening of the length of these operations as compared with the previous length to one-half to two-thirds, as well as on the conversion to the motor mode, the time for reaching a full load from which does not exceed 20-25 min, have been drawn up and coordinated with the Ural Turbomotor Plant as a result of the performed work.

However, the solution of a large number of questions, which are connected with ensuring the thorough discharging of TETs's during the minimum, is still required. Among them, in particular, are the rational location of additional pressure-reducing and cooling units and heaters of the network water for meeting the heat load during the period of the discharging of the turbines; the additional increase of the number of maintenance personnel and their material stimulation in connection with the complication of the operating conditions of TETs's in the maneuverable mode; the provision of the maneuverable equipment with the necessary means of automation for the maximum facilitation of control and the increase of reliability; the improvement and development of new methods which are aimed at increasing the maneuverability of the equipment (for example, heat storage); the assurance of the production of additional equipment (pressure-reducing and cooling units, heaters, means of automation and so on); the development of maneuverable cooling towers, which ensure year round the reliable operation of TETs's under different heat loads and weather conditions.

Unlike discharging during the minimum, the increase of the electric capacity of a TETs during the peak hours in excess of the nominal capacity (boosting), if it is accomplished by a decrease of the load of the takeoffs /7/, as a rule, requires the installation at the TETs of peak-load heat sources, and under present conditions the degree of economy of such a solution is decreasing. This is explained by the increase of the inclusive expenditures on fuel, the very high cost of peak-load coal-powered hot water boilers and the probable decrease of the cost of alternative peak-load electric power stations, which peak-load gas turbine power plants with the use of spent heat can be.

However, as the calculations of the All-Union Scientific Research Planning Institute of Power Systems and Electric Power Networks showed, considerably more economical means of boosting the electric capacity of TETs's during the peak hours by redistributing the heat loads in time are possible, which requires, however, additional study. The increase of the capacity of steam turbine TETs's during the peak hours by means of the disconnection of the high pressure heaters, as well as by the combining of TETs's with peak-load gas turbine power plants during the use of the heat of the exhaust of the latter for replacing the load of the takeoffs of the steam turbines /12/, which is possible both during the construction of new TETs's and during the renovation of operating TETs's, may also become very economical.

Conclusions

1. Under present conditions base-maneuverable TETs's, at which the thorough discharging during the minimum electric power loads is used, are the most economical source of the semipeak capacity in the power systems of the European part of the country with the shortage of water power resources.

2. The use of highly maneuverable TETs's does not diminish the advantage of the combined arrangement of power supply as compared with the separate arrangement.

3. With a considerable increase in the power systems of the proportion of nuclear electric power stations the maintenance in them of the proportion of TETs's in the amount of 30-35 percent will completely ensure the passage of the minimum electric power loads.

4. When building new TETs's engineering decisions are possible, which provide sufficiently economical means for obtaining an additional electric capacity during the peak hours.

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## ELECTRIC POWER AND POWER EQUIPMENT

UDC 621.315.1.027.3.064.2:005

# INTENTIONAL SHUTOFFS OF OVERHEAD LINES

Moscow ELEKTRICHESKIYE STANTSII in Russian No 11, Nov 79 pp 49-54

/Article by Candidate of Technical Sciences V. I. Edel'man, engineers I. G. Barg, S. V. Korobanov and T. P. Pripuskova, Ekonomtekhenergo-Soyuztekhenergo: "A Statistical Analysis of the Intentional Shutoffs of 35-500 kV Overhead Lines"/

/Text/ The intentional shutoffs of 35-500 kV overhead electric power transmission lines, to which all nonautomatic shutoffs usually belong, can be grouped, depending on the reason for the shutoff, in the following manner:

group I--shutoffs for the performance of the planned or unplanned repair or maintenance of overhead lines, the repair and replacement of components of overhead lines (wires, poles, insulators, cables), as well as shutoffs for top inspection, the examination of support terminals and others;

group II--shutoffs caused by the need to perform planned or unplanned repairs, maintenance or the renovation of adjacent equipment: sections of the busbars, to which the overhead lines are connected, the transformers in the line-transformer block, switches in the absence of bypass equipment and others. When assigning shutoffs to group II it is assumed that repairs or maintenance of the shut off overhead line are not performed. If both the overhead line and the adjacent equipment are being repaired simultaneously, the assignment of this shutoff to group I or II is determined depending of the main most important reason for the shutoff and on the evaluation of the possibility of postponing the shutoff of the overhead line to the period of the regular planned repair of this line;

group III--shutoffs for the renovation of the overhead line, which are connected with a change in the route of the line, the type of pole, the type of wires, with the connection of new leads and others. It is necessary to note that in practice some small amounts of renovation operations are performed at the same time as the regular planned repair of the overhead line. For example, when it is necessary to replace a wire because it is worn out, it is replaced by a wire of a greater gauge with allowance made for the prospects of an increase of the loads. Shutoffs of this type are assigned to group I;

group IV--shutoffs at the request of outside organizations for the performance of work in the zone of the electric power transmission lines. They are, as a rule, construction, installation, road construction and other types of organizations, which should perform work in the zone of overhead lines, and in conformity with the requirements of labor safety regulations and labor safety techniques for the performance of this work the overhead line should be shut off.

The existence of a certain interval of time between the making of a decision on the shutoff and the moment of the shutoff is the main common trait of the intentional shutoff of 35-500 kV electric power transmission lines.

The number of intentional shutoffs of 35-500 kV overhead lines during the year (see below) exceeds by a factor of 10 the number of breakdowns of these lines /1/, therefore the intentional shutoffs of overhead lines substantially affect the reliability of power supply systems. This circumstance is explained by the fact that many 35-kV overhead lines and the majority of 110-550 kV overhead lines, as a rule, are redundant and interruptions in the power supply of customers arise with the coincidence of the breakdowns of two mutually redundant overhead lines or with the coincidence of the breakdown of one of them with the intentional shutoff of the other. Since the total time of the intentional shutoffs of overhead lines is substantially greater than the total time of their restoration in case of breakdowns, the probability of the coincidence of a breakdown and an intentional shutoff is greater than the probability of the coincidence of breakdowns.

The volumes of work, which is performed during the repairs and maintenance of 35-500 kV overhead lines, generally also substantially exceed the volumes of restoration repairs with the exception of cases of large-scale damages. With intentional shutoffs, consequently, significantly greater expenditures of material and manpower resources occur. Many years of experience and the analysis of the type and nature of the work on repair and maintenance attest that the bulk of the failures of the components of overhead lines or the substantial decrease of their performance, which to a considerable extent determine the reliability and durability of overhead lines, are detected during intentional shutoffs. Thus, the data on the intentional shutoffs contain very representative information both on the reliability of the components of the overhead line and on the reliability of the electric power transmission line as a whole.

What has been indicatedattests to the need to take into account the intentional shutoffs of 35-500 kV overhead lines for solving three types of problems: the evaluation of the reliability of power supply systems, the increase of the reliability of the designs and the quality of installation of the overhead line and its components and the management of the production operations of the enterprises of the power supply systems. The information on intentional shutoffs, which is necessary for solving numerous problems, should be analyzed and processed depending on the demands which are made on it in the different problems. As a result a set of indicators can be obtained, which characterize the maintainability of 35-500 kV overhead lines depending on their design, the class of voltage, the material of the poles, the climatic zone and other factors and conditions of operation.

In this work the materials on 18,000 intentional shutoffs of 35-500 kV overhead lines during 3-4 years of operation, with a total amount of approximately 188,000 km-years, as well as standard reference data on all the overhead lines of the power systems, for which information on shutoffs was obtained, were used as the basic information for the evaluation of the indicated set of indicators.

Before establishing the nomenclature of the necessary indicators of the intentional shutoffs and the means of defining them, it is necessary to examine the peculiarities of the flows of events, which are connected with the intentional shutoffs of 35-500 kV overhead lines. The flow of intentional shutoffs of overhead lines can be regarded as the sum of two flows: the intentional planned shutoffs and the intentional unplanned shutoffs.

The shutoffs of the overhead line for planned repairs and renovation of the overhead line, the planned repairs of adjacent equipment and its renovation, as well as a portion of the shutoffs on the requests of outside organizations, which are submitted in due time and are included in the annual, quarterly or monthly plans, belong to the first flow. The shutoffs of this type cannot be regarded as random events, the sequence of the demands for these shutoffs forms a nonrandom determinate flow.

The flow of the restoration of an overhead line after the indicated shutoffs cannot be considered determinate, in spite of the fact that the length of the shutoff in each specific case is specified beforehand. When performing the work a number of random, unpredictable factors are in effect, which can influence the duration of the shutoff: weather conditions, a change in the amount of work, which was determined in the process of repair, control factors of the management of the power supply system and others. Thus, the duration of the intentional planned shutoff can be regarded as a random value and the moment of restoration as a random event, the sequence of such events forms a random flow.

The bulk of the shutoffs for repair operations, which are not included in the monthly, quarterly and annual plans and the need for which arises, as a rule, suddenly, first of all belong to the flow of intentional unplanned shutoffs of 35-500 kV overhead lines. The shutoffs of overhead lines due to similar repairs of adjacent equipment, as well as the unplanned requests of outside organizations also belong here.

It can be assumed with a sufficient degree of certainty that the demands for this kind of shutoffs of overhead lines are random, and their alternation forms a random flow.

The random nature of the cause of the unplanned intentional shutoff also determines the random nature of the duration of such a shutoff, consequently the flow of restoration is a random flow.

From the theory of waiting lines it is known that the sum of the determinate and random flows forms a new random flow. Thus, the flows of shutoffs and restorations during the intentional shutoffs of 35-500 kV overhead lines can be assumed to be random, while their parameters can be evaluated by means of the methods of mathematical statistics and the general theory of the reliability of technical systems.

The processing of the primary information by the methods of mathematical statistics makes it possible first of all to evaluate the two most important indicators of the indicated random flows--the average number of intentional shutoffs in a year and the average time of one intentional shutoff.

Usually the average number of intentional shutoffs in a year is written as two components

$$\mu = \mu_0 + \mu_L L, \tag{1}$$

where $\mu$ is the average number of intentional shutoffs in a year of an electric power transmission line with the length L; $\mu_0$ is the constant component of the average number of intentional shutoffs in a year of an overhead line of this type, which does not depend on the length of the overhead line; $\mu_L$ is the specific component of the average number of intentional shutoffs in a year of the overhead line in terms of a unit of length.

The processing of the initial information[1] showed that although for some regions in the range of the limited length of the overhead lines the average number of intentional shutoffs in a year is determined according to two components, on the whole for the bulk of the region it is possible to ignore the value of $\mu_L$.

This assumption can be applied both to the average number of intentional shutoffs in a year of the overhead line and to its components, which are classified according to groups I-IV. For groups II-IV such a conclusion does not require explanations. As to group I, the average number of shutoffs in a year of this type, as a rule, is assumed on the whole to be dependent on the length of the overhead line. However, a correlation analysis showed that with sufficient reliability in this case this parameter in practice also does not depend on the length of the overhead line (a similar conclusion is expressed in /2/). This circumstance is explained, in our opinion, by the fact that, first of all, the duration of the shutoffs of the overhead line is determined, as a rule, by the duration of the work shift; second, when it is necessary to perform a greater amount of work, the number of personnel is increased, and not the duration of the shutoff.

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[1] The program and calculations on computer were performed by engineer A. Markov (Soyuztekhenergo).

Table 1

| (1) Причина отключения | (7) Материал опор | (11) Среднее число преднамеренных отключений в год ВЛ напряжением, кВ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 35 | | 110 | | 220 | | 330 | | 500 |
| | | (12) Одноцепные | (13) Двухцепные | (12) Одноцепные | (13) Двухцепные | (12) Одноцепные | (13) Двухцепные | (12) Одноцепные | (13) Двухцепные | Одноцепные (12) |
| (2) Любая | Металл (8) | 2,5 | 3,3/0,4 | 3,5 | 4,0/0,6 | 3,3 | 3,2/1,1 | 4,0 | 8,7/0,3 | 4,9 |
| | (9) Железобетон | 1,7 | 2,4/0,2 | 2,2 | 3,0/0,5 | 2,5 | 2,5/— | 3,1 | — | 1,8 |
| | Дерево (10) | 3,3 | — | 4,2 | — | 5,1 | — | — | — | — |
| (3) Для ремонта или технического обслуживания | Металл (8) | 1,2 | 1,1/0,2 | 1,7 | 1,5/0,4 | 1,9 | 1,8/0,7 | 2,8 | 5,6/0,16 | 3,6 |
| | (9) Железобетон | 0,9 | 1,1/0,1 | 1,1 | 1,4/0,5 | 1,4 | 1,0/— | 2,1 | — | 6,5 |
| | Дерево (10) | 1,9 | — | 2,5 | — | 4,1 | — | — | — | — |
| (4) Для ремонта смежного оборудования | Любой (2) | 0,8 | | 1,1 | | 0,8 | | 0,6 | | 0,5 |
| (5) Для реконструкции | " | 0,2 | | 0,3 | | 0,2 | | 0,4 | | 0,3 |
| (6) По заявкам организаций | " | 0,3 | | 0,4 | | 0,3 | | 0,2 | | 0,3 |

Key:

1. Reason for shutoff
2. Any
3. For repair or maintenance
4. For repair of adjacent equipment
5. For renovation
6. At requests of organizations
7. Material of poles
8. Metal
9. Reinforced concrete
10. Wood
11. Average number of intentional shutoffs in a year of overhead lines with a voltage, kV
12. Single-circuit
13. Double-circuit

Note: For double-circuit poles the numerator is for the shutoff of one circuit, the denominator is for the shutoff of both circuits.

Table 2

| (1) | (7) | (12) 35 (13) | 35 (14) | 110 (13) | 110 (14) | 220 (13) | 220 (14) | 330 (13) | 330 (14) | 500 (13) |
|---|---|---|---|---|---|---|---|---|---|---|
| (2) | (8) | 11.4 | $\frac{10.8}{14.1}$ | 12.8 | $\frac{14.2}{14.3}$ | [illegible] | $\frac{[illegible]}{23.7}$ | 13.1 | $\frac{20.4}{14.1}$ | 22.0 |
|  | (9) | 12.8 | $\frac{9.8}{6.9}$ | 14.4 | $\frac{11.4}{11.3}$ | 18.4 | $\frac{13.1}{—}$ | 21.8 | — | 13.8 |
|  | (10) | 11.3 | — | 10.5* | — | 14.6 | — | — | — | — |
| (3) | (8) | 11.4 | $\frac{8.6}{12.3}$ | 11.9 | $\frac{15.7}{12.0}$ | 15.3 | $\frac{15.5}{17.9}$ | 15.3 | $\frac{29.1}{14.6}$ | 20.0 |
|  | (9) | 14.1 | $\frac{8.9}{7.9}$ | 14.7 | $\frac{17.0}{8.0}$ | 13.5 | $\frac{11.7}{—}$ | 21.6 | — | 13.5 |
|  | (10) | 10.8 | — | 10.7* | — | 60.1 | — | — | — | — |
| (4) | (11) | 8.2 |  | 15.1 |  | 31.0 |  | 17.7 |  | 29.6 |
| (5) | • | 17.7 |  | 23.6 |  | 45.5 |  | 27.5 |  | 47.0 |
| (6) | • | 10.[illegible] |  | 18.4 |  | 14.5 |  | 20.5 |  | 11.3 |

Key:

1. Reason for shutoff
2. For any reason
3. For repair or maintenance
4. For repair of adjacent equipment
5. For renovation
6. At requests of organizations
7. Material of poles
8. Metal
9. Reinforced concrete
10. Wood
11. Any
12. Average downtime during intentional shutoffs, hours, overhead lines with a voltage, kV
13. Single-circuit
14. Double-circuit

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* Disregarding lengthy shutoffs for several weeks.

Note: For double-circuit poles the numerator is for the shutoff of one circuit, the denominator is for the shutoff of both circuits.

The results of the calculation of the average number of intentional shutoffs in a year of 35-500 kV overhead lines and the average downtime of these overhead lines during intentional shutoffs are cited in Tables 1 and 2.

The data cited in Tables 1 and 2 attest to the following:

the average number of intentional shutoffs in a year of overhead lines for any reason increases with an increase of the rated voltage, the greatest value of the parameter corresponds to overhead lines on wooden poles, the least--to overhead lines on reinforced concrete poles. The average number of internional shutoffs in a year of single-circuit overhead lines is less than that of a single circuit of double-circuit overhead lines, since by the flow of the intentional shutoffs of one circuit of a double-circuit line there is meant the shutoff of each of the circuits separately;

the average number of intentional shutoffs in a year of overhead lines for the repair of adjacent equipment, renovation and at the requests of organizations virtually does not depend on the voltage of the line and is 1.9-1.8. The sum of these parameters is comparable in value with the average number of intentional shutoffs in a year of overhead lines for repair and maintenance. From this it follows that the increase of the readiness of 35-500 kV electric power transmission lines only by decreasing the number and duration of repairs has limits;

the average downtime of overhead lines during intentional shutoffs also increases with an increase of the rated voltage. The average downtime of overhead lines during an intentional shutoff for the repair of adjacent equipment, for renovation and at the requests of organizations is not only comparable in value with the average downtime of overhead lines during the intentional shutoff for repair or maintenance, but in a number of instances also exceeds it. In this connection the comparison of the indicators of the downtime of overhead lines during intentional shutoffs for repair and maintenance with shutoffs for other reasons is of interest. The coefficient of the downtime during intentional shutoffs is

$$K_{\text{п}} = \mu T_{\text{р}}, \qquad (2)$$

where $T_p$ is the average downtime of overhead lines during an intentional shutoff.

The results of the calculation of $K_{\pi}$ during the intentional shutoffs of 35-500 kV overhead lines due to the repair of adjacent equipment, renovation and at the requests of outside organizations in absolute terms (numerator) and as a percent of the total value (denominator) are cited in Table 3. The data of Table 3 make it possible to conclude that the reserves for increasing the readiness of 35-500 kV overhead electric power transmission lines consist not only in the improvement of its design and the organization of operation, but also in the rationalization of the layout decisions, the timely consideration of the prospects, the expedient choice of the routes, which takes into account the influence on the operating conditions of the overhead lines of intersections with roads, communications lines and others.

Table 3

| (1) Опоры | (9) Коэффициент простоя при преднамеренных отключениях ВЛ напряжением, кВ | | | | |
|---|---|---|---|---|---|
| | 35 | 110 | 220 | 330 | 500 |
| (2) Металлические, | | | | | |
| одноцепные (3) | 0,001/33 | 0,005/72 | 0,008/75 | 0,007/46 | 0,004/33 |
| (4) двухцепные, отключена цепь: | | | | | |
| одна (5) | 0,003/75 | 0,006/75 | 0,004/50 | 0,009/39 | — |
| (6) две | 0,0007/70 | 0,0015/75 | 0,002/75 | 0,0004/80 | — |
| Железобетонные: (7) | | | | | |
| одноцепные (3) | 0,002/66 | 0,002/50 | 0,001/20 | 0,003/37 | 0,006/37 |
| (4) двухцепные, отключена цепь: | | | | | |
| одна (5) | 0,002/66 | 0,002/50 | 0,003/75 | — | — |
| (6) две | 0,0001/50 | 0,0005/50 | — | — | — |
| Деревянные одноцепные (8) | 0,002/50 | 0,005/50 | 0,035/50 | — | — |

Key:

1. Poles
2. Metal
3. Single-circuit
4. Double-circuit, circuit is shutoff
5. One
6. Two
7. Reinforced concrete
8. Single-circuit wooden
9. Coefficient of downtime during intentional shutoffs of overhead lines with a voltage, kV

The planning of the shutoffs of 35-500 kV overhead lines for repair or maintenance, the organization of preliminary work, the need for manpower and means of mechanization should be based on the standards of the duration and number of shutoffs of overhead lines for the performance of operations of a specific type on them. In turn the use of statistical data on such shutoffs, which are differentiated by types of operations (Table 4), is one of the ways of elaborating standards of the intentional shutoffs for repair and maintenance. The data cited in Table 4 can also be used when standardizing the stock of materials depending on the length, voltage and material of the poles of the overhead lines in operation, as well as for compiling the optimum plan of the comprehensive repair of electric power transmission lines. The coordination of the repair and maintenance of electric power transmission lines and the adjacent equipment of substations can be carried out according to these data.

Taking into account that repair and maintenance are a means of maintaining the reliability of overhead lines in the process of operation, the data cited in Table 4 can serve as the basic information for making decisions on the increase of the reliability of the lines by the improvement of its components. In particular, in practice for all voltages the main type of repair of overhead lines is the replacement of the insulators. Moreover, with an increase of the rated voltage the proportion falling to this type of operations increases.

Table 4

| (1) Род работы | (15) [illegible] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (16) [illegible] | | | | | (17) [illegible] | | | | | (18) [illegible] | | |
| | 35 | 110 | 220 | 330 | 500 | 35 | 110 | 220 | 330 | 500 | 35 | 110 | 220 |
| (2) Опоры: | | | | | | | | | | | | | |
| замена (3) | 5.1 | 3.4 | 0.3 | 1.2 | 1.4 | 20.5 | 6.3 | 1.6 | 2.1 | 0.0 | 17.2 | 0.4 | 31.0 |
| (4) выправка | 1.2 | 1.3 | 0.6 | 0.2 | 0.0 | 4.1 | 1.2 | 4.3 | 1.1 | 0.0 | 3.2 | 2.9 | [illegible] |
| окраска (5) | 5.0 | 4.3 | 0.2 | 4.5 | 1.2 | 3.6 | 3.1 | 4.8 | 0.4 | 2.0 | 0.2 | 1.0 | [illegible] |
| (6) ремонт | 4.4 | 1.4 | 0.1 | [illegible] | 1.2 | 4.6 | 4.6 | 3.2 | 0.7 | 2.0 | 36.0 | 43.3 | 4.7 |
| (7) Провод: | | | | | | | | | | | | | |
| замена (3) | 2.8 | 4.0 | 2.2 | 0.7 | 0.4 | 1.2 | 2.7 | 0.0 | 0.7 | 0.0 | 3.1 | 1.6 | 2.4 |
| регулировка (8) | 2.8 | 2.3 | 0.3 | 1.2 | 0.4 | 2.5 | 1.7 | 0.5 | 0.0 | 0.0 | 1.4 | 1.3 | 2.4 |
| (9) ремонт, включая арматуру | 14.4 | 12.7 | 4.1 | 4.8 | 3.6 | 7.1 | 12.0 | 4.8 | 6.7 | 0.0 | 6.3 | [illegible] | [illegible] |
| (10) Изоляторы: | | | | | | | | | | | | | |
| замена (3) | 21.8 | 32.2 | 63.8 | 75.5 | 80.0 | 22.6 | 36.4 | 55.1 | 68.8 | 91.3 | 14.0 | 20.8 | 19.1 |
| (11) чистка | 17.5 | 17.1 | 0.6 | 1.9 | 0.0 | 4.8 | 8.4 | 4.8 | 1.4 | 0.0 | 1.4 | 0.3 | 0.0 |
| (12) Трос: | | | | | | | | | | | | | |
| замена (3) | 3.2 | 6.4 | 4.4 | 0.7 | 0.4 | 1.1 | 2.2 | 1.1 | 0.7 | 0.0 | 2.4 | 1.0 | 0.0 |
| (6) ремонт | 1.2 | 2.5 | 5.0 | 1.2 | 4.0 | 0.8 | 3.9 | 1.5 | 3.2 | 0.0 | 2.5 | 1.0 | 19.1 |
| (13) Расчистка трассы | 2.3 | 2.2 | 1.9 | 0.7 | 0.4 | 4.3 | 3.4 | 3.2 | 1.1 | 0.2 | 2.3 | 2.0 | 0.7 |
| (14) Работы по техническому обслуживанию | 8.2 | 9.1 | 4.7 | 4.8 | 8.0 | 15.5 | 14.2 | 8.0 | 7.1 | 4.5 | 8.2 | 8.3 | 1.8 |

Key:

1. Type of job
2. Poles
3. Replacement
4. Straightening
5. Painting
6. Repair
7. Wire
8. Adjustment
9. Repair, including armature
10. Insulators
11. Cleaning
12. Cable
13. Clearing of route
14. Maintenance operations
15. Average number of shutoffs as a percent of the total number of shutoffs of overhead lines with poles
16. Metal
17. Reinforced concrete
18. Wooden

It is also necessary to note the high percentage of shutoffs which are undertaken for the replacement and repair of wooden poles, as well as the repair of the reinforced concrete poles of 35-kV overhead lines. The replacement and repair of wooden poles are connected, as a rule, with the rotting of the wood and more rarely with the break of crosspieces or uprights of the pole. This circumstance again forces us to devote attention to the quality of the preservation of wooden poles, uprights and crosspieces.

The high percentage of shutoffs, which are connected with the repair of reinforced concrete poles, is governed first of all by the need to carry out the straightening of the poles with inadequate embedding in the ground.

The analysis shows that the intensity of storm activity in the region through which the route of the electric power transmission line passes has an influence on the number of damages to the insulators in the chains and, consequently, on the need to replace them by way of preventive repair. The coefficients cited in Table 5 show the correlation of the values of the average number of intentional shutoffs in a year for the repair and maintenance of overhead lines in different storm regions of the USSR (taken in conformity with the Rules for Setting Up Electrical Installations).

Table 5

| (1) | (2) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 35 | | | 110 | | | 220 | | 330 | |
| | (3) | (4) | (5) | (3) | (4) | (5) | (3) | (5) | (3) | (5) |
| 1 & 2 | 0.8 | 0.7 | 0.7 | 0.5* | 0.4* | 0.4* | 0.8* | 1.0* | 0.4* | 0.9* |
| 3 | 1.0 | 1.0 | 1.0 | 1.0 | 0.7 | 1.0 | 1.0 | 1.1 | 0.5 | 1.0 |
| 4 | 1.2 | 1.2 | 1.3 | 1.3 | 0.9 | 1.5 | 1.4 | 1.2 | 0.7 | 1.2 |
| 5 | 1.4 | 1.5 | 1.7 | 1.5 | 1.2* | 2.0 | 1.6* | 1.3 | 1.0* | 1.4 |
| 6 & 7 | 1.5 | 1.8 | 2.0 | 1.6 | 1.4* | 2.5* | 1.8* | 1.3* | 1.2 | 1.5 |

Key:

1. Storm region
2. Storm coefficient for overhead lines with a voltage, kV
3. Wooden
4. Metal
5. Reinforced concrete

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*Approximate figures due to the limitation of data.

The analysis of the intentional shutoffs of 35-500 kV overhead lines shows that during the year the number of shutoffs is distributed very irregularly.

The values of the coefficients of the seasonal nature of the shutoffs, by the use of which it is possible to determine the average number of intentional shutoffs in a year of 35-500 kV overhead lines for different periods of the year, are cited in Table 6, and the length of the corresponding period changes depending on the temperature zone /3/ in which the overhead line is located.

Table 6

| (1) Напряжение, кВ | (2) [illegible] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | I | | II | | III | | IV | | V–VI | |
| | (3) Зима XII–II | (4) Лето III–XI | (3) Зима XI–III | (4) Лето IV–X | (3) Зима XI–IV | (4) Лето V–X | (3) Зима X–IV | (4) Лето V–IX | (3) Зима IX–V | (4) Лето VI–VIII |
| 35 | 0,6 | 1,1 | 0,7 | 1,2 | 0,7 | 1,3 | 0,8 | 1,3 | 0,8 | 1,6 |
| 110 | 0,4 | 1,2 | 0,6 | 1,3 | 0,7 | 1,3 | 0,7 | 1,4 | 0,7 | 1,9 |
| 220 | 0,5 | 1,2 | 0,5 | 1,4 | 0,8 | 1,2 | 0,8 | 1,3 | 0,8 | 1,6 |
| 330 | 0,5 | 1,2 | 0,6 | 1,3 | 0,6 | 1,4 | 0,7 | 1,4 | 0,7 | 1,9 |
| 500 | 0,6 | 1,1 | 0,8 | 1,1 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |

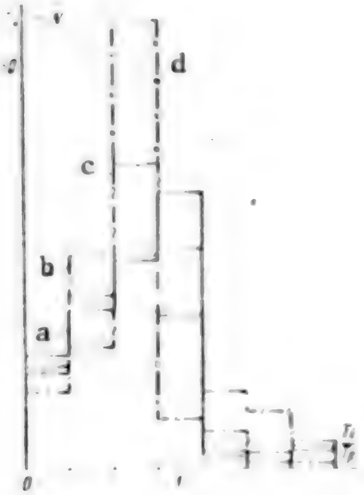
Key:

1. Voltage, kV
2. Seasonal coefficients for temperature zone
3. Winter
4. Summer

In order to determine the value of the average number of intentional shutoffs during the year for the repair or maintenance of an overhead line, which is located in a given temperature zone, during the corresponding period of the year it is necessary to multiply the value of the parameter from Table 1 by the corresponding value of the coefficient of the seasonal nature from Table 6.

The considerable variation of the number of shutoffs of overhead lines during the year reflects the seasonal nature when organizing repairs and maintenance. The summer and winter periods are used as much as possible for the performance of planned operations on overhead lines. During the winter period according to the conditions of the cycle the shutoffs of overhead lines are allowed considerably less often, at the same time the conditions of the performance of work during this period are complicated, which leads to an increase of labor inputs on maintenance. During the winter period a portion of the planned work remains, which they did not have the time or for one reason or another we unable to perform in the summer.

The use of the characteristics of the maintainability of 35-500 kV overhead lines in the calculations of the reliability of power supply systems in a number of cases requires data not only on the mathematical expectation and standard deviation of these indicators, but also on the laws of their distribution. The evaluation of the laws of distribution require considerable calculations, the use of tables of special functions and tests of goodness of fit. At the same time a simple practical method is known, which makes it possible without considerable calculations to determine the form of the law of distribution and to establish its parameters. The use of this method is especially advisable in the case of the processing of data for a large number of similar characteristics with a presumably (due to technical considerations) similar law of distribution, but with different values of the parameters of the law. This method consists in the use of probability paper.



Bar Charts of the Distribution of the Length of Intentional Shutoffs

a--35-kV overhead line on metal poles, single-circuit, shutoffs for any reason; b--330-kV overhead line on reinforced concrete poles, double-circuit, shutoffs of both circuits for any reason; c--220-kV overhead line on metal poles, single-circuit, shutoffs for repair or maintenance; d--110-kV overhead line on wooden poles, single-circuit, shutoffs for repair or maintenance.

The check of the hypothesis on probability paper consists in the estimation of the closeness to a straight line of the statistical function of distribution, which was built on it. From the figure it is evident that the probability density of the value of the duration of the intentional shutoffs is of a modal nature, is asymmetrical and has meaning on the interval of time $t > 0$. Distributions of this type are described well by the Weibull-Gnedenko law, the function of which is

$$F(T) = \begin{cases} 1 - \exp\left(-\frac{T^{\gamma}}{\beta}\right) & T \geq 0; \\ 0 & T < 0, \end{cases} \qquad (3)$$

where $\gamma$ is the parameter of the form of distribution; $\beta$ is the characteristic parameter.

A merit of the indicated distribution is its flexibility, that is, the great diversity of the forms of the function of distribution (3), and the fact that the normal, Rayleigh and exponential distributions are a special case of this distribution given $\gamma$ which is equal respectively to 1, 2 and 3.5.

Box charts of the distribution of the duration of intentional shutoffs for any reason and for the repair and maintenance of overhead lines of several types are cited in the figure as an example. The hypothesis about the Weibull-Gnedenko law with respect to these dependences is confirmed satisfactorily with the construction of the same characteristics on probability paper. The same characteristics, but constructed on probability paper for a distribution of a different type, differ more significantly from a straight line.

The results of the determination of the characteristics of the Weibull-Gnedenko distribution with respect to several types of overhead lines (shutoffs for any reason and for repair and maintenance) are cited in Table 7. The characteristics were obtained by graphical means on probability paper (the method of obtaining them is described in /4/).

Table 7

| (1) | (2) | (6) |  | (9) |  |  |  |
|---|---|---|---|---|---|---|---|
|  |  | (7) | (8) | (10) |  | (11) |  |
|  |  |  |  | β | T | β | T |
| [illegible] | (3) | 1 | 1 | 11.6 | 1.4 | [illegible]3.0 | 19.6 |
|  |  | 2 | 1 | [illegible] | [illegible] | [illegible] | [illegible] |
|  |  |  | 2 | 14.9 | 1.6 | [illegible] | 1.9 |
|  | (4) | 1 | 1 | 33.1 | 1.6 | 44.7 | 1.7 |
| [illegible] | (4) | 1 | 1 | 54.6 | 1.8 | 77.9 | 2.0 |
|  | (5) | 1 | 1 | 16.5 | 1.7 | 27.1 | [illegible] |
|  |  | 2 | 1 | 33.1 | 1.8 | 54.6 | [illegible] |
|  |  |  | 2 | 9.0 | 1.8 | 27.1 | 7.2 |
| [illegible] | (3) | 1 | 1 | 30.0 | 1.6 | 44.7 | 1.8 |
|  |  | 2 | 1 | 6.7 | 0.8 | 3.5 | 0.5 |
|  | (5) | 1 | 1 | 7.4 | 1.1 | 5.5 | 1.0 |
| [illegible] | (3) | 1 | 1 | 11.5 | 1.2 | [illegible] | 1.5 |
|  | (5) | 1 | 1 | 14.2 | 1.2 | 27.8 | 1.2 |
| [illegible] | (3) | 1 | 1 | 10.0 | 0.8 | 9.0 | 0.7 |

Key:

1. Voltage, kV
2. Material of poles
3. Metal
4. Wood
5. Reinforced concrete
6. Number of
7. Circuits
8. Shut off circuits
9. Shutoff
10. For any reason
11. For repair or maintenance

The study of the box chart of the distribution of the average number of intentional shutoffs in a year of 35-500 kV overhead lines showed that it is possible with respect to these distributions to advance the hypothesis of a normal law of distribution. The check of the hypothesis on the appropriate probability paper yields satisfactory results.

The parameters of the normal distribution of the average number of shutoffs in a year of several types of overhead lines (shutoffs for any reason and for repair and maintenance) are cited in Table 8. The parameters were obtained by a mathematical means:

the mathematical expectation

$$\bar{\mu} = \frac{\sum_{i=1}^{m} N_i}{\sum_{i=1}^{m} k_i \tau_i}; \tag{4}$$

the standard deviation

$$\sigma = \sqrt{\frac{\left(\Sigma\bar{\mu} - \frac{N_i}{k_i \tau_i}\right)^2}{\sum_{i=1}^{m} k_i}}, \tag{5}$$

where m is the number of enterprises of the power supply networks, for which information was gathered; $N_i$ is the number of intentional shutoffs of the overhead lines at enterprises of the power supply networks; $k_i$ is the number of overhead lines at the enterprises of the power supply networks; $\tau_i$ is the number of years, for which information on the given enterprise of the power supply network is available.

Table 8

| (1) | (2) | (6) | | (9) | | | |
|---|---|---|---|---|---|---|---|
| | | (7) | (8) | (10) | | (11) | |
| | | | | μ | σ | μ | σ |
| [illegible] | (3) | 1 | 1 | 3.3 | 1.8 | 1.0 | 1.2 |
| [illegible] | (4) | 1 | 1 | 2.2 | 2.0 | 1.1 | 1.4 |
| | | 2 | 1 | 2.0 | [illegible] | 1.4 | 1.6 |
| | | | 2 | 0.5 | 1.1 | [illegible] | 0.6 |
| | (3) | 1 | 1 | 4.2 | 3.4 | [illegible] | [illegible] |
| [illegible] | (5) | | | [illegible] | [illegible] | 1.6 | [illegible] |
| | | 2 | | [illegible] | [illegible] | 1.6 | 1.6 |
| [illegible] | (5) | | 2 | 1.1 | 2.5 | 0.7 | 1.7 |
| | | 1 | 1 | 4.0 | 3.0 | 2.8 | 1.4 |
| | (5) | 1 | 1 | [illegible] | [illegible] | [illegible] | [illegible] |

Key:

1. Voltage, kV
2. Material of poles
3. Wood
4. Reinforced concrete
5. Metal
6. Number of
7. Circuits
8. Shut off circuits
9. Shutoff
10. For any reason
11. For repair or maintenance

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# REPAIR OF HIGH-PRESSURE CABLE LINES

Moscow ELEKTRICHESKIYE STANTSII in Russian No 11, Nov 79 pp 55-59

/Article by engineer G. P. Makiyenko, Kama Cable Plant: "The Repair of 220-500 kV High-Pressure Cable Lines"/

/Text/ At present about 50 high-pressure cable lines in a steel pipe for a voltage of 220, 330 and 500 kV have been installed and are in operation at the operating hydroelectric power stations of the USSR. The use of these lines at a number of hydroelectric power stations, which are under construction and are being planned, is called for.

The high-pressure cable line in a steel pipe consists of the following main components: terminal boxes, copper tubes of the splices with the cable, splice or coupling-splice boxes, a steel pipe with the cable, coupling boxes, cable leads to the transformers, an oil level maintenance unit.

Cables of the brands MVDT--oil-filled, high-pressure, in a lead casing which is removed at the site of laying with the drawing of the cable into the pipe, and MVDTk--high-pressure, which is delivered in a container with oil, are used for building these cable lines.

Domestic cable plants can produce high-pressure cables with copper current-conducting cores with a section of 300, 400, 500 (550), 625 (700) mm$^2$ for a voltage of 220 kV; 400, 500 (550), 625 (700) mm$^2$ for 330 kV; 500, 625 (700) mm$^2$ for 500 kV. The cables having the sections indicated in parentheses are produced in some cases on agreement between the customer and the manufacturing enterprise.

Work is being performed on the placement into production of cables with a section of the core of 850 and 1,000 mm$^2$.

A shield made of several strips of semiconducting carbon paper and one two-color semiconducting strip, which is wound with the insulation layer facing the insulation, is applied to the copper current-conducting core. The shield is intended for the smoothing of the irregularities on the surface of the core and the absorption of the products of the aging of the oil when it circulates from the core to the insulation.

The part of the insulation, which is adjacent to the current-conducting core, is made from strips of compressed paper 0.08 mm thick, while the remaining layers are made from paper of normal density with a thickness of 0.12 and 0.17 mm.

The rated thickness of the paper insulation of cables, which is soaked in S-220 oil, is shown in the table.

| Nominal section of the core, $mm^2$ | Rated thickness of insulation of high-pressure cable, mm | | |
|---|---|---|---|
| | 220 kV | 330 kV | 500 kV |
| 300 | 20.7 | -- | -- |
| 400 | 19.1 | 25.0 | -- |
| 500 | 18.1 | 24.0 | -- |
| (550) | 18.1 | 24.0 | 31.0 |
| 625 | 17.5 | 23.0 | 30.0 |
| (700) | 17.5 | 23.0 | 30.0 |

A shield made from one strip of two-color paper with the insulation layer facing the insulation, strips of semiconducting paper, one strip of metallized semiconducting paper with the metal on the outside and one perforated copper strip is applied to the insulation.

The thickness of the shields on the core and insulation for 220-kV cables is equal to 0.3 and 0.6 mm, 330-kV and 500-kV cables--0.45 and 0.7 mm. Two semicircular copper sliding wires of 2.5 X 5.0 mm, which protect it and the insulation from damage when drawing the cable into the pipe, are applied to the shield on the insulation.

The rated thickness of the temporary lead casing is 2.8 mm with a diameter of the cable under the casing of 50-70 mm, 3.3 mm with a diameter of 70-90 mm and 3.6 mm with a diameter of 90-110 mm.

The pipe for the cable line is welded from steel seemless pipes 9-12 m each in length with a wall thickness of 10 mm, at the ends of which there are sockets with a taper of 1 : 10. When joining two pipes a lining ring is inserted in their sockets. The internal diameter of the pipes is selected to be 2.4- to 2.65-fold larger than the diameter of the cable around the sliding wires. The external diameters of the steel pipes are 219 mm for 220-kV cable, 245 mm for 330-kV cable and 273 mm for 500-kV cable.*

Along with the cable for constructing high-pressure cable lines the cable manufacturing enterprise supplies: terminal, splice, coupling-splice and coupling boxes, unfinished steel and copper tubes, insulating oil for filling the line, the oil level maintenance unit. The size of the delivery is determined when coordinating the plan of the cable line with the cable manufacturing enterprise.

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*I. Ye. Veyts, L. A. Kuznetsov, A. V. Tyurin, "Opyt sooruzheniya na gidroelektrostantsiyakh kabel'nykh liniy v stal'nykh trubakh s maslom pod davleniyem" /The Experience of Constructing at Hydroelectric Power Stations Cable Lines in Steel Pipes With Oil Under Pressure/, Moscow, Informelektro, 1969.

The construction of high-pressure cable lines in a steel pipe is carried out by specialized installation organizations according to the instructions and with the supervisory installation of the cable manufacturing enterprise.

The necessary equipment and technology for performing repair operations have been developed for the repair of cable lines in case of their failure in operation. The procedure of performance, the amount and duration of the repair operations are determined by the type of damage to the cable line.

In case of the damage of the cable in the steel pipe the grounding of one of the cores occurs and in this case on the cable of the two other phases the strips of the insulation shield are damaged. With a breakdown of the cable the pressure in the cable line momentarily increases approximately twofold. The oil pressure in the line during operation is $1.4 \pm 0.2$ MPa. The zone of damage of the cable line is determined by the loop method or other methods, and then the site of the damage is made more precise directly on the steel pipe by the acoustic method with an accuracy of several centimeters.

One of two methods of repair with replacement of the three phases of the cable in the steel pipe is undertaken by the operating and installation organizations and the cable manufacturing enterprise:

the replacement of the damaged structural length of the cable between the boxes;

the replacement of the cable on the damaged section with the installation of additional boxes.

When replacing the three phases of the cable in the steel pipe of the cable line between the coupling boxes the arrangement of the equipment and tools, the installation of an oil level maintenance system, the construction of installation platforms are carried out according to the layout indicated in Figure 1.

The maintenance of the oil level of the cable line during the repair period is carried out from the oil level maintenance unit or the degasification plant. In this case a special oil line made from metal pipe 40-60 mm in diameter is installed between the undamaged sections of the cable line.

Branch pipes with flanges are welded to the steel pipe at a distance of not less than 6 m from the freezing units, in order to eliminate an increase of the viscosity of the oil at the point of their connection during the freezing of the cable. Holes approximately 16 mm in diameter are drilled in the pipe and bellows valves are installed on the flanges. An oil pipe is laid between the valves, which is evacuated and filled with oil, and a pressure gauge for monitoring the oil pressure in the line is installed on it.

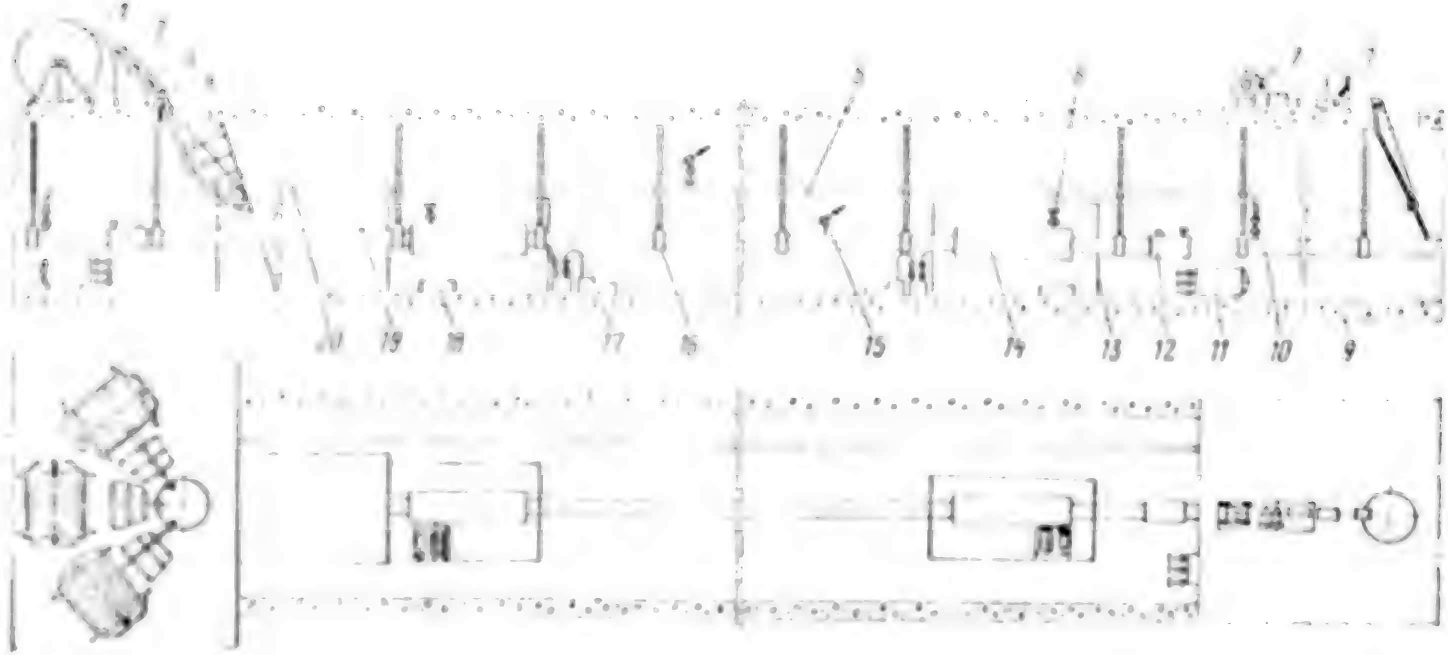

Figure 1. Diagram of the Location of Equipment During the Replacement of the Structural Length of Cable in the Steel Pipe of a Cable Line Between Coupling Boxes.

1--cable drum; 2--cable; 3--pay-out unit; 4--guide rollers; 5--pipe of the oil level maintenance system; 6--bellows valve; 7--cable-laying winch; 8--device for recording stress forces; 9--tunnel for cable line; 10--steel pipe with cable; 11--liquid nitrogen tank; 12--freezing device; 13--tent for installing the coupling box; 14--coupling box; 15--pressure gauge; 16--supports for securing the pipe with the cable; 17--vacuum pump with an overflow tank; 18--winch for cleaning the pipe; 19--platform for removing the lead casing; 20--tent for removing the lead casing.

Platforms for the installation of the boxes and the cable drums are built, the tents, the winch and the other equipment necessary for the laying of the cable are set up.

The unit for freezing the cable (Figure 2) in the steel pipe is installed on the pipe at a distance of not less than 6 m from the adapter ring of the coupling box. The housing of the unit is made from a sheet of metal 1-2 mm thick, there are two holes in the top of the housing: one for pouring the liquid nitrogen and the other for monitoring the level of its pouring. The length of the unit between the rubber sealing gaskets is taken to be not less than four external diameters of the steel pipe, while the clearance between the surfaces of the pipe and the unit is taken to be equal to 10 mm. Heat insulation is applied to the freezing unit.

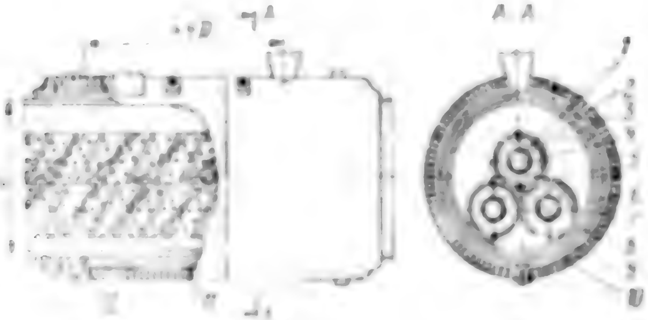

Figure 2. Freezing Unit, Which Is Installed on the Steel Pipe of a High-Pressure Cable Line

1--current-conducting core; 2--core shield; 3--insulation; 4--insulation shield; 5--sliding wires; 6--insulating oil; 7--steel pipe; 8--liquid nitrogen; 9--freezing unit; 10--collar; 11--heat insulation; 12--rubber gasket.

Liquid nitrogen tanks with a capacity of 1,000-1,400 l are installed as close as possible to the freezing unit and are connected to it by two or three hoses, each 3 m long. If it is impossible to install the tank near the place of freezing of the cable, the liquid nitrogen is transferred manually in Dewar flasks with a capacity of approximately 30 l.

The freezing of the cable in the steel pipe is carried out. During the freezing the liquid nitrogen is poured until the unit is completely filled and the level of pouring is monitored by the boiling of the nitrogen on the surface of the pipe.

Until the unit is completely filled the nitrogen is poured for 30-60 sec, the intervals between pourings and the duration of freezing for each interval are cited below.

| Intervals between pourings of liquid nitrogen | Duration of freezing |
|---|---|
| 10-40 sec | 30-40 min |
| 2-4 min | 1.5-2 hr |
| 15-20 min | 4-6 hr |
| 30 min | 4-6 hr |
| 45 min | 4-6 hr |
| 1 hr | Until completion of repair |

The freezing of the cable is monitored by a pressure gauge, which is installed on the steel pipe of the section of cable line being repaired, by the decrease of the oil pressure in the pipe to zero.

Before the start of the freezing the oil pressure in the top center of the pipe is adjusted to 0.05-0.15 MPa and is maintained during the entire period of repair. In 5-6 hr after the start of the freezing of the cable in the pipe the created plugs are tested for tightness for 30 min with an increase of the pressure in the cable line by 0.3 MPa.

The oil is poured out of the steel pipe of the line between the plugs. The coupling boxes, the housings of which are moved to the steel pipe of the section of cable line being repaired, are removed. Seals, which are connected with the adapter rings of the coupling boxes, are installed on the ends of the cables, which come out of the steel pipes of the undamaged sections of the cable line. The end sections of the steel pipe and the seals are evacuated and filled with dried nitrogen.

If the laying of the cables in the pipe and the installation of the boxes are not carried out immediately after the removal of the damaged cable, the evacuation and filling of the seals with oil after the unfreezing of the plugs are carried out.

The damaged cable is removed from the steel pipe and the latter is plugged and filled with dried nitrogen.

Three structural lengths of cable are laid in the steel pipe of the cable line. Seals, which are connected with the adapter rings of the coupling boxes, are installed on the ends of the cables, which come out of the pipe. The pipe with the laid cable is evacuated and filled with nitrogen.

The installation of the coupling boxes is carried out. When installing the box the section of the pipe with the cable from the adapter ring to the plug should be filled with gaseous nitrogen to eliminate the condensation of moisture on the internal surface of the pipe and the moistening of the paper insulation.

The pipe with the cable and the boxes are evacuated and filled with oil after the unfreezing of the plug which is located at the bottom center on the repaired section of cable line. Then the second plug is unfrozen. A pressure of 1.4 ± 0.2 MPa is established in the cable line, the sampling of the oil, tests for determining the gas content in the cable line and the preparation of the latter for charging are carried out.

When repairing a cable line by replacing the cable in the pipe in the damaged section the length of the section, on which the cable should be replaced, is determined. At the site of the damage of the cable at a distance of 12 m on both sides of it connecting pipes are welded to the steel pipe, holes are drilled and a sample of the oil for tests is taken. At the site of the damage of the cable the oil has a dark color.

If there are traces from the breakdown of the cable in the oil or it has unsatisfactory characteristics, a further sample of oil is taken from the pipe every 5 m in the direction of the ends of the cable line.

The oil should have an electric strength $E_{st}$ with a voltage of alternating current with a frequency of 50 Hz and an oil temperature of 20 ± 10°C of not less than 180 kV/cm, a tangent of the angle of dieletric losses tg$\delta$ with an electric field intensity of 10 kV/cm and an oil temperature of 100 ± 1°C of not more than 0.01.

The installation of connecting pipes and the sampling of oil from the pipe are carried out until satisfactory test results are obtained.

In the case of the damage of the cable on a horizontal section satisfactory test results of the oil samples, as a rule, are obtained at a distance of 17-22 m in the direction of the end of the cable line, to which the oil level maintenance unit has been attached, and approximately 12 m in the direction of the other section of the line.

The sites of the cutting of the pipe and the installation of adapter rings are marked on the steel pipe from the connecting pipes in the direction of the end sections of the cable line at a distance of approximately 70 percent of the length of the housing of the coupling box. The preliminary work for replacing the cable on the damaged section is performed. A pipe for the oil level maintenance system is assembled, the freezing units are installed, installation platforms for the installation of the boxes and the laying of the cable and the tents over the boxes are built, the equipment for laying the cable is installed, sections of cable and steel pipes are delivered to the repair site. The diagram of the arrangement of the equipment and tools is depicted in Figure 3.

The distance between the adapter rings of the coupling boxes, which are installed during the repair of the cable line, is determined, and the welding of a steel pipe for the repair of the line is carried out in accordance with the obtained quantity. Adapter rings are welded to the butts of the pipe and the housings of the coupling boxes are slid onto the pipe. The three phases of the cable, on the end sections of which the seals connected with the adapter rings are installed, are laid in the pipe. The pipe with the cable is evacuated and filled with nitrogen. The freezing of the cable in the pipe is carried out.

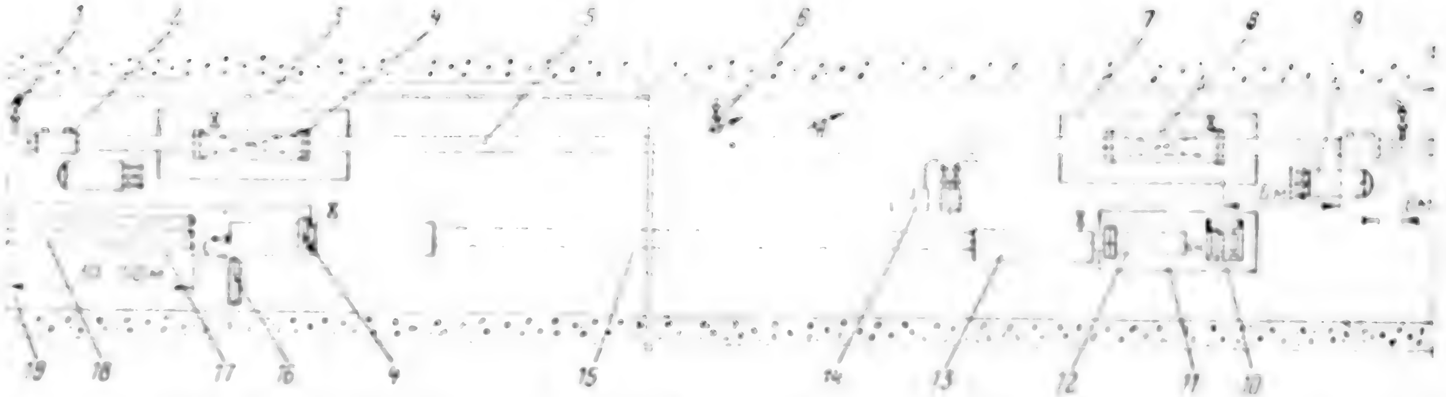

Figure 3. Diagram of the Arrangement of the Equipment During the Replacement of the Cable in the Steel Pipe in the Damaged Section of a Cable Line

1--bellows valve; 2--unit for freezing the cable in the pipe; 3--oil line; 4--adapter ring of the coupling box; 5--steel pipe of the cable line; 6--pressure gauge; 7--platform for installing the coupling box; 8--coupling box, which is installed during the repair of the cable line; 9--liquid nitrogen tank; 10--winch; 11--installation platform; 12--seal; 13--housing of the coupling box; 14--vacuum pump with overflow tank; 15--steel pipe for repairing the cable line; 16--nitrogen tank; 17--platform for the cable and the removal of the lead casing; 18--cable for repairing the cable line; 19--tunnel for the cable line

The oil is drained from the section being repaired and the pipe with the cable is cut at the connecting pipes which were installed on the pipe for sampling the oil. The steel pipe with the cable is removed from the site of the performance of the repair work. The ends of the cables of the damaged sections of cable line are marked when cutting the pipe with the cable. The steel pipe is cut with a pipe cutter at the places where the adapter rings of the coupling boxes were installed. Heat insulation is applied to the cable at the places where the cables come out of the pipe, and adapter rings are welded to the pipe.

Seals, which are connected with the adapter rings, are installed on the ends of the cables, which come out of the pipe. The seals and the sections of pipe with the cable up to the sites of freezing are evacuated and filled with nitrogen. A section of steel pipe with the cable is installed in place of the damaged section of cable line. The installation of the coupling boxes is performed. The pipe with the cable and the boxes are evacuated and filled with oil.

When replacing the cable in a damaged section it is necessary to remove from the steel pipe the gas that was liberated during the breakdown. The actual control points of the installation of the steel pipe and the boxes at a distance of 100-150 m from the site of the damage in the direction of the section of the line, to which the oil level maintenance unit was connected, and at a distance of approximately 50 m in the direction of the other section of the line, are specified.

If the cable was damaged at a distance of several tens of meters from the coupling box, which was installed on the side of the connection of the oil level maintenance unit, the gas will basically be concentrated in the housing of the box. When laying a pipe with a cable on a horizontal section the gas will be located in the top center of the pipe on the sections which have slightly greater control points of installation, since in practice it is not possible to ensure the laying of the pipe on a single level. In this case the steel pipe with the cable in several places along its length is raised several centimeters by lifting devices, connecting pipes are welded on, holes are drilled and the oil is drained until the complete disappearance of the gas bubbles in the oil.

In the case of the replacement of the cable on a damaged section, when laying the cables the lead casing is removed by hand, while when laying the structural lengths the casing is removed by lead-stripping machines or by hand, if it is impossible to use lead-stripping machines. The duration of the laying of a cable with the removal of the casing by hand and with the use of lead-stripping machines is approximately the same. With a length of the cable on the drum of approximately 300 m the laying is performed in 8-9 hr. A special tool for the longitudinal and lateral cutting of lead casings has been developed for removing the lead casing by hand and at each phase 5-6 people directly remove the casing.

When repairing cable lines in a steel pipe:

the cable in the steel pipe is frozen for 3-4 hr, the consumption of liquid nitrogen for creating one plug is 600-700 l, when performing repair work 15-20 l/hr are consumed per plug, the number of personnel per freezing unit is 2 people per shift;

the thawing of the cable in a steel pipe is carried out in 5-7 hr with a temperature on the surface of the unit of 50-60°C, which is created by hot air blowers;

the duration of the repair of a cable line in the case of the replacement of the structural length when performing the work without interruption from the start of the freezing to the charging of the cable line is 14-16 days, including: the freezing of the pipe with the cable, the removal of the coupling boxes, the installation of seals and their filling with nitrogen, the removal of the damaged cable, the preparation of the steel pipe for the laying of the cable take 5-6 days; the laying of the cable, the installation of two coupling boxes, the evacuation and filling of the pipe with the cable with oil, the preparation of the cable line for charging take 9-10 days;

the duration of the repair work when replacing the cable in the damaged section is 8-10 days;

for the laying of the structural length of cable the number of installation personnel per shift is 32-35 with the removal of the lead casing by hand and 18-20 people with the use of lead-stripping machines;

the work on laying the sections of cable in a steel pipe is performed by 13-15 people.

The technology of repairing high-pressure cable lines in a steel pipe, which was presented in this article, was used when repairing 500-kV cable lines. There have been no reproofs on the operation of the cable lines during use since the performance of the repair work.

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ELECTRIC POWER AND POWER EQUIPMENT

# IMPROVING THE EFFICIENCY OF THERMAL POWER STATION REPAIR SERVICES

Kiev ENERGETIKA I ELEKTRIFIKATSIYA in Russian No 3,Jul-Sep 79 pp 1-5

[Article by V.F. Sklyarov, Deputy Minister of Power Engineering and Electrification of the Ukrainian SSR]

[Text] Assuring high operational reliability of the equipment and structures, as well as their constant operational readiness, places high requirements on the organization of repair services for TES's [thermal electric power stations] and the management of power engineering repair operations.

Positive results, which are cited in the table, have been achieved in recent years in the organization of TES repairs.

The systematic increase in the level of centralization of repair operations, the fabrication of spare parts, the introduction of industrial repair methods and improving the mechanization of the work all facilitated the attaining of these results.

However, power engineering repair work still does not come up to the high requirements placed on it.

Equipment shutdowns for unplanned repairs, violations of the deadlines set for repairs and the time periods between repairs are permitted. The turnover of repair personnel is high.

Progressive forms of repair work organization, the efficiency of which has been confirmed by practice, are slow to be introduced.

Taking this into account, as well as the enormous outlays of labor and material resources for repairs, it is essential to devote considerable attention at all levels of management to questions of increasing the efficiency of repair services for TES's.

The management of the repair and technical servicing of the equipment of electrical power stations represents one of the most complex areas of

TABLE

| Показатели Indicators | Years Годы | | | | | | | | Прирост, % к 1973 г |
|---|---|---|---|---|---|---|---|---|---|
| | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | |
| 1. Коэффициент готовности энергоблоков, %: | | | | | | | | | (4) |
| 200 МВт MW | 87,0 | 86,0 | 86,3 | 85,5 | 87,1 | 87,1 | 86,7 | 86,5 | |
| 300 МВт | 83,0 | 84,1 | 85,5 | 86,9 | 87,8 | 88,9 | 87,1 | 87,6 | 2 |
| 800 МВт | 61,7 | 57,1 | 77,2 | 82,0 | 74,2 | 67,4 | 78,2 | 80,1 | 3 |
| 2. Межремонтный период энергоблоков, год: | | | | | | | | | |
| 200 МВт | 3,1 | 3,3 | 3,7 | 4,0 | 3,6 | 3,8 | 4,0 | 4,1 | 14 |
| 300 МВт MW | 1,7 | 2,2 | 2,9 | 2,9 | 2,9 | 3,6 | 4,0 | 3,11 | 42 |
| 3. Удельная численность ремонтного персонала ТЭС, чел/МВт | 0,95 | 0,89 | 0,84 | 0,85 | 0,85 | 0,84 | 0,8 | 0,78 | 9 |

Key: 1. Operational readiness factor of the power units, %;
2. Period between repairs of the power units, years;
3. Specific manpower factor for TES repair personnel, man/MW;
4. Increase, in percent, referenced to 1973.

management in power engineering. The diversity of repair service facilities their design and technological complexity, the lack of stereotypes for the work to be done, and the colocating of design, production process and generation functions in one enterprise make the work of engineering and technical personnel extremely complex and responsible.

The realiable and economic operation of equipment today depends to an ever greater extent on the level of organization of repair services, the quality of the repair and the efficient work of the repair enterprises.

However, the underestimation of the importance of the technological preparation for repairs has still not been entirely eliminated in repair enterprises.

Over recent years, no small amount of engineering documentation (more than 300 documents developed in the ERP [power engineering repair enterprises] of Dneproenergo alone, directed towards improving repair technology, has been developed by the departments of the main process engineers and by the designers of the offices of power engineering repair enterprises. Their incorporation in the production process amounts to 15 - 25 percent. Developments for technological equipping and curtailing the percentage of manual labor (seven percent introduced) are being handled and introduced in an especially slow fashion.

The TsKB [central design offices] of Glavenergoremont [main power engineering repair administration] have developed the technological processes, standards for labor outlays, resource, component and assembly outlays, as well as for the management of equipment repair for practically all of the equipment of electrical power stations. The supervision of the introduction of the TsKB materials and the local developments of the subdivisions of the repair enterprises has not been set up.

The exchange of experience between repair enterprises has not been widely developed yet. The engineering services and management of the ERP's are making practically no use of the fall and winter break in the repair campaign for these purposes.

The ERP enterprises of Dneproenergo, Kievenergo and Khar'kovenergo devote attention to the exchange of experience more than others. They exchange developments, assist in their realization, and go on business trips to the enterprises of the Glavenergoremont: to Mosenergoremont, Kaunasenergoremont, Estonenergoremont, etc.

In the 1976, the ministry organized a trip for managers and specialists of the PEO's [Power Engineering Planning Organizations] and the ERP's to study the experience with the organization of the planning and conduct of equipment repairs at the enterprises of Belglavenergo and Latvenergo.

Based on the introduction of the experience of the enterprise of Belenergoremnaladka [Belorussian Power Engineering Repair Work

Arrangement Administration], a plan was developed on the basis of the proposals of the ERP's. Some two years have passed, but only the ERP of L'vovenergo has implemented computerized calculations of labor expenditures.

The repair department and TsBTI [Central Office of Technical Information] of the Ukrainian SSR Ministry of Energy have done a great deal of work to generalize and dissemenate the experience of power engineering repair enterprises. Informational letters on new engineering items, better efficiency expert proposals which have been introduced at each enterprise, as well as plans for the design and process engineering operations of the ERP's during 1976-1978 were sent to all TEO's and ERP's. The Ministry has received one response from the PEO's and ERP's to requests concerning the utilization of these materials: we are studying which have partially used this information, with the exception of the ERP of Dneproenergo. Such an approach generates parallelism in the work and holds back an improvement in the technical level and growth in labor productivity.

The electrical power stations and repair enterprises with the subdivisions of the TsKB of Glavenergoremont are doing considerable and effective work to increase the technical level of repair work.

The implementation of these developments is directed towards increasing the reliability and operating economy of electrical power station equipment, as well as improving the organization and technology of the repairs.

Some 139 developments were carried out over the period 1975-1978 by the subdivisions of the TsKB, including those for repair organization amounting to 32, 52 structural designs developments and 55 in technology.

As of 1 January, 1979, 71 repair operations were completely introduced or 51 percent, 21 repair operations or 15 percent had been partially introduced and 47 operations, or 34 percent, were not introduced.

The economic impact derived from the introduction of TsKB developments in repair work amounts to more than two million rubles. The greatest number of developments were carried out for the PEO's of "Khar'kovenergo" - 34, 31 for the "Dneproenergo" PEO's, 22 for the Donbassenergo" PEO's, and 19 for the "L'vovenergo" PEO's.

However, a third of these operations have still not been introduced in the PEO's cited here. It should be noted that the Dneproenergo ERP is devoting greater attention to this work than others, and for this reason, the economic effect of the introduction of the developments for them is the highest: 570,000 rubles.

It is essential to continue in subsequent years the fruitful cooperation with the TsKB of Glavenergoremont and to plan greater developments for the nuclear power stations of the Ukraine.

The "Dneproenergo" PEO can serve as a good example of the organization of this work, which was the first in 1978 to allow the start of the specialization of the mechanical operations at the Zaporozhskaya GRES for the fabrication of the fuel oil injectors of the TKZ [not further defined] and the spare parts for the fuel oil pumps; and at the Krivorozhskaya GRES, the shafts for the MV, VGD and DRG [not further defined], the dredging pumps, the housings of the bearings of the slag transporters, spare parts for the shaker mechanisms of the electrostatic filters; at the Pridneprovskaya GRES, the injectors for the DGU [not further defined], the fastenings of the pulverizers, the nozzles of the GZU [not further defined], etc.; at the Dneprodzerzhinskaya TETs, the screw clamps, grounding devices, cable cutters, tongs for the heat welding of lines, shears for cutting wrappings and devices for replacing insulators; and at the Krivorozhskaya TETs, the fastenings for dredger pumps and other equipment, the fingers of couplings and accessories for centering pipes.

The manufacture of spare parts in the sectors will amount to 25 percent overall of the total reserve of machine tool time for mechanical operations.

The production volume of spare parts can in this way be increased in each power system by 300,000 - 500,000 rubles annually.

The mechanization of repair work represents a serious problem, which is one of the critical factors in raising labor productivity in repair work, and it is not accidental that this question has been receiving increasing attention of late.

In recent years, the designers of the ERP and TsKB offices of Glavenergoremont have developed and fabricated a large number of various mechanization devices, repair equipment and mechanized tools. Specialized subdivisions and sections for the mechanization of the "Remenergomekhanizatsiya" enterprise of Glavenergoremont have been created at electrical power stations, something which should promote the work according to plan on the mechanization of repair operations.

However, at the present time, the repair work done using mechanization means by the sections of "Remenergomekhanizatsiya" amounts to 15 percent of the overall demand based on the quantity and products list.

For this reason, it is necessary for the power engineering repair enterprises to devote attention to developments and the fabrication of mechanization means in the mechanical shops and at repair bases. It is expedient to organize brigades in the sections which would work out the structural design of a mechanical tool under the supervision of the ERP services of the power systems.

At the present time, the level of mechanization of repair operations at electrical power stations amounts to 43 percent. Several labor intensive operations do not have any mechanized accessories at all. This especially applies to boiler clearing, boiler setting and heat insulation operations.

The average level of the mechanization of the repair of a boiler unit amounts to 19 percent, 20 - 30 percent for auxiliary boiler equipment and 37 percent for a turbine set.

The machine-worker ratio for repair personnel is especially low in the "Donbassenergo" PEO at 170 rubles/man, 160 rubles/man in the "Dneproenergo" PEO and 130 rubles/man in the "Khar'kovenergo" PEO, which must be brought up to 250 rubles/man based on the standards of the TsKB of Glavenergoremont.

Some work is being accomplished in this regard by the power systems. Project plans have been introduced for the comprehensive mechanization of operations at the Uglegorskaya, Kurakhovskaya, Krivorozhskaya GRES-2 and the Zaporozhskaya GRES. Individual operations are being mechanized at other TES's. However, the manufacture of mechanization gear by repair enterprises amounts to 280,000 rubles in all, and the annual plans are being 70 percent implemented.

Greater attention must be devoted to the mechanization of repair operations on the 800 MW units, as well as for the mills of all block unit GRES's.

The ministry has prepared a plan for the manufacture of mechanization equipment by the power engineering repair enterprises on a cooperative basis in 1980, in accordance with which materials and component products will be provided.

The organization of their production by the repair enterprises will promote an increase in the machine-worker ratio for repair personnel and a reduction in the percentage of manual labor in repair work.

It is specifically the development of these trends which will permit an improvement in the technical and economic indicators of power equipment operation in the future, as well as assure reliable and economic operation of electrical power stations.

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# ELECTRIC POWER AND POWER EQUIPMENT

## PROBLEMS AT EKIBASTUZ GRES CONSTRUCTION PROJECT DISCUSSED

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 30 Nov 79 p 1

[Article by B. Glotov, Ekibastuz, Pavlodar oblast: "A Prisoner of Assurances"]

[Text] The slogan "We shall produce a million kilowatts in 1979!" appears above the entrance to the main building of the Ekibastuz GRES-1 which is under construction. It is still hanging there, although everyone already knows that the promised kilowatts will not be there. They somehow forgot to take it down, or were not able: it is fastened too high up. And just a few weeks ago, the construction site was literally plastered with these kinds of appeals. Among them was also a display on which the days were counted off which remained until the start of the first power unit with a capacity of 500,000 kilowatts. They planned to place it on-line on the 25th of September of this year, but it didn't work out. And there is no talk at all about the December start of the second unit.

"Yes, things didn't turn out well with the slogan," says the brigade leader of the installation workers of the "Sibelektromonazh" Trust, V. Moiseyev. "And the workers took them seriously, and several interesting initiatives were taken on the construction project. The brigade of Vasiliy Sizintsev, for example, came foreward as the initiator of a competition for the right to throw the knife switch. Our collective took on shock labor duties in order to place the first "500,000 kilowatter" in service on time. And now we see that the start of the first power unit has been put off for an indefinite period of time."

Why was there a disruption at the finish? I put this question to the chief of Glavenergostroy of the USSR Ministry of Energy, G. Aksenov, who as the curator of the construction project is located in Ekibastuz, as well as to E. Filatov, the manager of the "Ekibastuzenergostroy" general contracting trust.

"In the year for the start of service, we figured on carrying out this maneuver: at first, the main efforts were to be concentrated on the main building, to finish it," they replied, "and thereafter, the auxiliary facilities were to be 'finished off' in a synchronized manner. But unfortunately, the intention did not completely succeed. We did not finish things in the main building within the plan deadlines. Things dragged on a great deal longer than was planned. No hands at all ever got to the auxiliary facilities, without which the power unit cannot be started."

This outcome is not accidental. As it turned out, the managers of the construction project guided the collective towards the start of the first two power units as permitted by the Ministry of Energy without a clearcut program and precise schedule. The station is being built in the steppe, at a fair distance from large industrial centers. And you see, this always entails difficulties in the delivery of materials, equipment and the housing of personnel. Nonetheless, four years ago the builders immediately set about the construction of production facilities. Without their own industrial base, and without housing.

They really got down to work only in the last year, when the general contracting trust, "Ekibastuzenergostroy", was created and the "Energostroyindustriya" trust was created for getting materials together. But with only these measures, the volume of work performed in this year in the amount of 56 million rubles proved to be inadequate.

"There is a shortfall of more than a thousand workers at the construction project right now," relates the party committee secretary, G. Zaychenko, "numerous skilled builders and installation workers are ready to come to us, and we cannot receive them. There is no housing! It was planned that 80,000 square meters would be placed in service for us this year. And we shall bring practically no more than 50,000 square meters. For the remaining housing, we were not supplied with the panels and other products by the Bratsk, Naberezhnochelninsk, Verkhnetagil'sk and Nazarovskiy plant for steel reinforced concrete products and structures."

All of the enterprises cited here are subordinate to the ministry of energy. "You know," admits the chief of Glavenergostroy, G. Aksenov, "it is not so simple to have an effect on them. Not infrequently, they work in their own local interests at these plants, and for this reason, they disrupt deliveries of materials and prefabricated structures for housing in Ekibastuz."

There are also other no less weighty reasons for the disruption of the start of the two power units. Multiple shift work has not yet been set up at the construction project, and the losses in work time and downtimes in the mechanisms are large. There is not the requisite order on the sites where the equipment and materials are unloaded. The builders and installation workers must specially assign people who spend hours searching in the warehouses for the products which have been dumped any which way. In the situation which has developed, it would be impossible to count on success. So wouldn't it be more honest to admit that the plan deadline is unrealistic? But neither G. Aksenov nor E. Filatov decided to pose this question. They just didn't have the heart. Right up to the very last minute they were reporting to the ministry that the two power units with a capacity of one million kilowatts would be brought in on schedule. These reports lulled both themselves and others. They were believed. Some two weeks prior to the "start" of the first power unit, G. Aksenev, at the overall trust party meeting, nonetheless called upon the communists to put the pressure on, speed up work, although he knew himself: the question could never be one of bringing the facility in on time.

"And what was I supposed to say?" wonders the chief of the main administration at a loss. "You see I could not dampen the enthusiasm of the personnel. Or was I wrong?"

Wrong. Because as the director, and a communist, he did not tell the people the truth. For you see, they are not indifferent to the fate of the construction project.

Of course, after everyone found out that the deadlines for the start of the facilities had been extended, it did not become worse to work in the construction and installation collectives. However, notes of dissatisfaction creep in a little bit into various conversations. It is felt that the people are upset, that the collective has not kept its word.

When then will the station be started up? A precise answer could not be obtained to this question. "We shall try to bring in the first unit by the end of the year," E. Filatov unconfidently announced. This "vague" timetable is again not backed up by either precise engineering calculations or organizational measures. The September disruption did not become a serious lesson for the managers of Glavenergostroy and the "Ekibastuzenergostroy" trust.

The Ekibastuz GRES-1 is in essence the first large fuel power engineering complex of its kind built east of Kazakhstan. The importance of placing it on line as fast as possible was underscored once again by comrade L.I. Brezhnev in his address to the November (1979) Plenum of the CPSU Central Committee. In it, an object lesson was assigned to all participants in the construction project: clean up the production process; and the management organs were tasked with providing the projects with everything they need.

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# ELECTRIC POWER AND POWER EQUIPMENT

## HOUSING PROBLEMS FOR SMOLENKSK AES BUILDERS

Moscow STROITEL'NAYA GAZETA in Russian 7 Dec 79 p 2

[Article by V. Kapel'kin, Smolensk oblast: "Alongside the AES"]

[Text] In the USSR Ministry of Energy, they came up with the idea of creating a standard setting settlement alongside the Smolensk Nuclear Power Station*. A collective of designers was also found who were inspired by this idea: the TsNIIEP [Central Scientific Research Institute for Experimental Design and Planning] for school buildings.

And then on the sheets of drafting paper there appeared the outlines of the so called primary service units, housed under one roof with the residential apartments. In each unit there is a cafe-dining hall, a self-service laundry room, a department for placing orders, rooms for quiet games and independent activities, and a children's room. And adjoining the buildings were the general settlement centers: for trade, schooling, administrative, cultural and educational, municipal services, . . ..

The designers also knew how to look at the problem through the eyes of builders. They proposed a standardized panel and frame series of steel reinforced concrete components, the "UK-1", for all of the residential and social and cultural public service facilities, where this series can be produced by any type of DSK [housing construction combines] without substantial changes in the equipment. And just such a housing construction enterprise was erected on the as yet uninhabited banks of the Desna.

However, the institute proposes, while the ministry, the customer and the subcontractor in one person, disposes. While in various instances the designers were congratulated on the successful developmental work, the construction of the enterprise for the large panel products approached the end. But instead of targeting it for the production of the "UK-1" products, the plant unexpectedly was provided with the forms for the production of the "84" standard series. As it was explained, the USSR Ministry of Energy did not provide timely specific instructions concerning the experiement, and it was decided on the spot to travel the well trodden path, and therefore the easier one.

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*An article on the problems of constructing the Smolensk AES itself was published in the preceding issue.

Thus, the good intentions of constructing the standard setting settlement were actually crossed out. And then the USSR Ministry of Energy even designates another institute as the designer: Gidroproyekt, which developed the new project plan, by working from those series which were already being used here.

It would seem, one can just shrug one's shoulders: but so what, they say, it was a beautiful start, but they went back to the commonplace, and also a not bad variant. In all it was written off as a loss in the archive of the project plans of the TsNIIEP for schools buildings. If only it were so! But even this variant is not being brought to life. The construction of the residential housing using the "84" series is hopelessly behind the preliminary plans. About 3,000 Desnogorska residents are now still living in little trailers, and this number is not being reduced. However, though things are moving slowly here, there is nonetheless motion. The construction of the social and cultrual public services facilities has almost come to a standstill, literally as if they decided in the Ministry of Energy to run a durability test on their own builders and operational workers: what is the minimum of domestic conveniences and how long can they make do.

The intention of constructing the social and cultural public services facility of brick and imported steel reinforced concrete has not proven out in practice. At the end of the ninth year of the construction of the electric power station, there is one school, one kindergarten, one small club with 30 seats, and one store for foodstuffs and indistrial goods for the 13,000 residence of the settlement. Tens of other social, municipal services and public serivces facilities exist as yet only in project plans or in the form of foundations, and unfinished boxes.

And just how do the Desnagorska residents make do? The school runs in three shifts. Mothers, instead of working on the construction site, sit at home with young children. They travel to other cities to go shopping. It is better not to get sick in Desnogorska. With even a slightly serious illness and the medial clinic which is sheltered in an attached room will not be able to help you. You have go to Roslavl' or Smolensk.

In the settlement you will not go to the movie, you will not bathe in the public bath, you will not sew a coat and you will not turn your linens over to the laundry.

It is hardly surprising that people rarely settle here. In the construction administration for the Smolensk AES, not a year goes by but that the total is as follows: a few more than a thousand are taken on and a few less than a thousand are dismissed.

The situation would be partially improved by getting the following underway: the public trade center in the first microrayon, the baths with the laundry, the warehouses for foodstuffs and industrial goods, a health clinic for 60 patients, four built in stores and other facilities. But they are being constructed extremely slowly.

And then the forgotten idea of the standardized "UK-1" series, proposed by the TsNIIEP of school buildings for Desnogorsk has been resurrected in the minds of the local builders: there, they say we are to build the social and cultural public serivces and dormitory facilities from the same panels as the residences!

The present difficulties in the construction of the village arose as a consequence of the customary poor management. Was it really not known beforehand that relying on imported steel reinforced concrete structures was risky, and that there was a large deficit of brick in the Smolensk oblast? Besides this, brick construction is labor intensive, and this means, additional workers hands are needed. And you see, the project plan of TsNIIEP of school building promised not only a high degree of comfort and progressive services, but an industrial execution using standardized structures for all of the settlement facilities. The need for brick and imported steel reinforced concrete was itself eliminated. But no farsightedness was apparent in the ministry of energy.

In the sector, its own system of high capacity structural and installation organizations has been created for the construction of GES's, GRES's and AES's. Only one organization specializes in municipal construction through: the Soyuzenergozhilstroy Association. Its specialty is residential housing. The social and cultural public service facilities though - better in some areas and worse in others - are constructed at odd moments by the general contractor for the electric power stations. Just as in Desnogorska.

And as for the DSK leaders in the outfitting with the standardized "UK-1" series, there would be a single general contractor for the village responsible for the entire construction site complex.

In the latest decisions of the members of the ministry, and in the written instructions of the minister, P. Neporozhniy, numerous steps are provided to speed up the work on the first power unit of the Smolensk AES. There are words in them concerning the increase the pace of residential construction. In the meanwhile, according the program project plan, the serivces being provided have even been somewhat curtailed as compared to last year's plan. And what if the same thing happened with the social and cultural public services.

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ELECTRIC POWER AND POWER EQUIPMENT

UDC 621.165

# EXPERIENCE WITH THE T-250/300-240 CENTRAL HEATING TURBINES

Moscow ENERGETIK in Russian No 9, Sep 79 pp 1-3

[Article by N.I. Serebryanikov, V.D. Kudryavyy and Ye.K. Kuznetsov, Engineers]

[Text] In our country, providing central heat is one of the basic ways of satisfying the continually growing demands for heat by industry and housing and municipal services in large cities, and in this case, a trend is noted towards a constant enlargement of the heat supply sources and the per unit capacities of the plants.

In the development of the district heating of Moscow, the basic unit for a long time was the T-100-130 turbine. During the Ninth Five-Year Plan, a district heating power unit with a unit capacity of 250 MW, 340 GCal/h came to replace it (Figure 1).

The design of the unit, which has a supercritical pressure, steam temperature and intermediate superheating, has made it possible to match the parameters of high power condensation and district heating plants.

A substantial improvement was achieved in the basic design indicators for the UMTZ [Urals Turboengine Plant] T-250/300-240 turbine as compared to the T-100-130 turbine. The specific electrical power output per heat consumption was increased by about 20 percent, while the specific fuel consumption in condensation modes was reduced by 10-12 percent.

According to design calculations of the VTI [All-Union Order of the Red Banner of Labor Heat Engineering Institute imeni F.E. Dzerzhinskiy], the use of the T-250/300-240 turbines reduces the annual consumption of conventional fuel by no less than 40,000 tons. The specific weight of the turbine installation has been reduced by more than 17 percent. The overall mation economic impact from the use of one unit with a T-250/300-240 turbine amounts to about 4.5 million rubles.

Power units with T-250/300-240 turbines are reliable, highly economical and flexible plants. Over the last 1977-1978 heating season, they generated

9.5 million GCal or 18.6 percent of the total amount of heat in the Mosenergo [Moscow District Power Administration] system, and utilization coefficients of 80.4-90 percent were achieved for the electrical power and 68-93.3 percent for the thermal power.

The specific fuel consumption during 1978 amounted to 232.4 g/KWH. In the winter heating period, the units operated with a specific consumption of 186-239 g/KWH; the best indicator of 170.1 g/KWH was achieved in the station No. 5 unit, TETs-23 [central heating and power plant 23] in February of 1978, with an average monthly load of 221,100 KW and 313.5 GCal/h.

A number of problems came up during the period of placing the T-250/300-240 turbine on line, the solution of which required the combined efforts of the collective of Mosenergo, the manufacturing plants, as well as project planning, scientific research and set-up organizations.

The most complex problem proved to be the limiting of the electrical and heat power in connection with the inadequate vibration stability and the appearance of intense low frequency vibration at a steam load of 70-80 percent of the nominal. It was determined that the basic causes for the reduction in the stability were the excitation of vibration in the TsVD - PsSD [high pressure cylinder - low pressure cylinder] rotors by the aerodynamic forces of the steam flow in the case of nonuniform flow through the gaps above the shrouding strips, as well as by the elastic forces of the oil layer in the support bearings.

The vibrational stability threshold of the T-250-240 shafting proved to be lower than that of the K-300-240 condensation plant, because of the lighter intermediate pressure rotor and the significantly lesser loads on the supports. The higher steam pressure in the regulating stage chamber (by 18 kgf/cm$^2$) caused greater aerodynamic perturbation forces in the first stages of the turbine and in the intermediate labyrinth seals of the rotor.

An additional negative factor was the unstable position of the support structures for the turbine installation, due to the insufficient stiffness of the foundation and the increased axial forces during thermal displacements of the turbine.

A complex of work was carried out in 1974-1975 to eliminate the low frequency vibration, where this work made it possible to assure full loading of th units at the price of a slight reduction in operating economy.

Turbine shrouds of a new structural design of the UTMZ were installed in the TsVD in December of 1975 during the installation of the turbines, station No. 9 of TETs-21 and station No. 5 of TETs-23 through the efforts of the repair personnel of the TsRMZ [Central Repair and Machine Plant] of Mosenergo. They assured the design operating economy of the flow-through section and the absence of low frequency vibration throughout the entire load range. This made it possible to recommend them for introduction on all P-250/300-240 turbines, and not only in the TsVD, but also in the TsSD-1 [medium pressure cylinder 1]. A new structureal design of the foundation with strengthened cross bars, which has been used on turbines since 1977, was developed to increase the stability of the turbogenerator supports in the case of thermal displacements of the turbine by the Leningrad branch of the Teploelektroproyekt VGPI [not further defined]. Along with this, it is expedient to use new types of lubricants for such heavy turbines, where these provide for a lower coefficient of friction between the bearing support and the foundation slab as compared to a graphite lubricant.

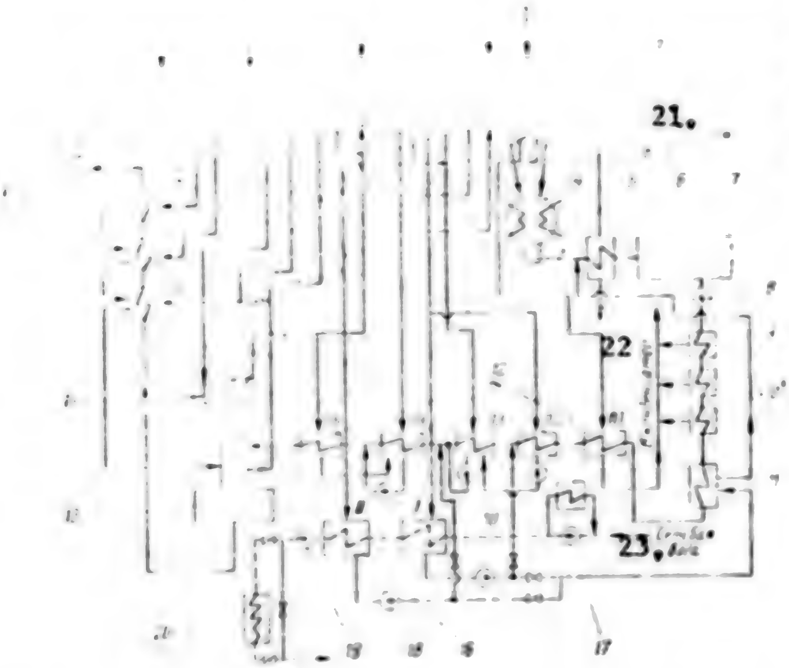

Figure 1. The basic heat circuit of the T-250-240 turbine set.

Key: 1. Boiler; 2. Turbine; 3. Generator; 4. Condenser; 5. Stage I condensate pump; 6. Stage II condensate cooler; 7. Condensate cleaning; 8. Stage II condensate pump; 9. Ejector cooler; 10. Steam seals cooler; 11. Stage I condensate cooler; 12. Low pressure preheaters; 13. Deaerator; 14. Feed pump; 15. High pressure preheaters; 16. Mains preheaters for stages I-II; 17. Stage I mains pump; 18. Condensate pumps of the mains preheaters for stages I-II; 19. Stage II mains pump; 20. Peak hot water boiler; 21. Circulation water; 22. To the condenser; 23. Mains water.

An important measure was taken in 1976-1977 to improve the economy of the turbine sets: their changeover to a counter pressure mode. The aerodynamic and strain gauge studies of the operation of the flow through portion of the low pressure cylinder show that this mode is the most crucial.

As compared to the T-100-130 turbine, the operating conditions of the latter stages, when the steam flow in the TsND [low pressure cylinder] is reduced below 100 tons/h, deteriorate because of the intermediate superheating of the steam and its higher temperature.

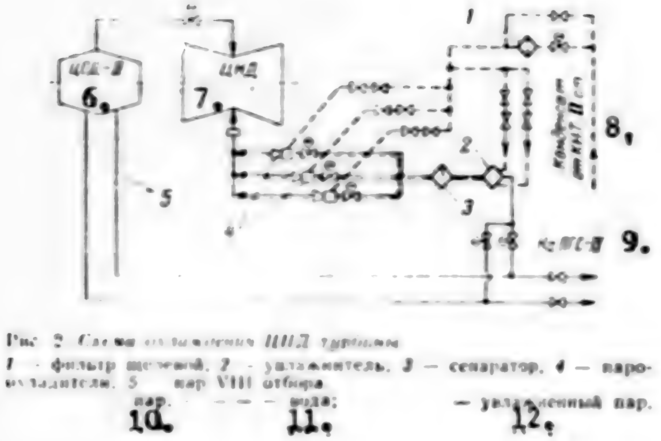
ЦСД-II
6.
ЦНД
7.
1
2
3
4
5
8.
к ПГС-II
9.
Рис. 2 Схема охлаждения ЦНД турбины
1 – фильтр щелевой, 2 – увлажнитель, 3 – сепаратор, 4 – пароохладители, 5 – пар VIII отбора
пар;
10.
— — — вода;
11.
— увлажненный пар.
12.

Figure 2. The cooling circuit for the turbine low pressure cylinder.

Key: 1. Slot filter; 2. Humidifier; 3. Seperator; 4. Steam coolers; 5. Steam of bleed line VII; 6. TsSD-II [immediate pressure cylinder II]; 7. TsND [low pressure cylinder]; 8. Condensate from the KNT [not further defined] of stage II; 9. To the PGS-II; 10. Steam; 11. Water; 12. Humidified steam.

Mosenergo, in conjunction with the plant, carried out the requisite tests and accomplished the retrofitting of a specially designed circuit for feeding damp and bleed-off steam to the TsND from a heating bleed line (Figure 2). This made it possible to completely close off the access of the "hot" steam to the TsND and reduce the consumption of cooling steam down to 25-30 tons/hours.

The temperature of the TsND exhaust pipes in this case does not exceed 70-80° C. The overall fuel savings in this mode due to the reduction of heat losses from the cooling water amounts to no less than 8 g/KWH or 6 to 7 thousand tons of conventional fuel annually.

Limitations on the electrical power were ascertained during the process of operating the turbines for the case of single stage heating of the mains water for the hot water tap. This is the typical summer mode for Moscow with the water heated up to a temperature of 70-75° C, which corresponds to a pressure in the lower bleed line of 0.5 kgf/cm$^2$; the circulation of the mains water amounts to about 5,000 m$^3$/h for return water temperatures of 40-55° C; the heat output is about 100 GCal/h.

The instructions of the plant place a number of limitations on operation with a single stage heating. The full steam flow to the turbine can be obtained at a pressure in the lower bleed line of 0.75 kgf/cm$^2$ which corresponds to heating the water up to 90° C, i.e., "overheat" operation. Bypassing the mains water by the boiler is permitted to a limited extent, since no less than 30,500 m$^3$/h should pass through the boiler, otherwise, there is the danger of buildup in the pipes. In this case, the temperature of the mains water following mixing still exceeds the specified level and amounts to 83° C. To reduce the pressure in the lower bleed line down to 0.5 kgf/cm$^2$, it is reduce the steam flow to the turbine down to 750 t/h, something which leads to a reduction in the electrical power of the unit down to 230,000 KW.

The limiting of the flow of live steam with respect to the pressure in the chamber of the lower heating bleed line was due to the endangering of the strength of the rotor blades of the intermediate section between the I and II heating bleed lines.

To remove the limitations, the plant has planned a series of tests to check the possibility of the operation of the flow through section of the turbine when the pressure in the bleed line is reduced.

During the period of placing the power units with the T-250/300-240 turbine om-line, considerable attention was devoted to the working out of the start-up and shut-down modes. Tests demonstrated that the set is a flexible unit, having characteristics close to power units with the K-300-240 turbines.

To improve the reliability and flexibility of the turbines in variable operating modes, the system for heating the flanges and studs was rebuilt, in a manner similar to that for the 300 MW capacity condensation turbines, and the ROU [not further defined] for heating the intermediate steam superheater was eliminated. This permitted not only a simplification of the start-up circuit, but also a reduction in the time needed bring the plant up to the nominal power from a cold start down to seven hours, and down to three hours following an eight hour shutdown.

The operational economy of the turbine and set as a whole at partial loads can be substantially improved by using power regulation with "live steam pressure slip", which was tested and used for the first time in the station No. 9 TETs-22 turbine (in a set with the TPP-210A boiler).

The results of tests showed that it is expedient to shift the unit over to "sliding pressure", beginning at the point in time the fifth control valve is closed (which corresponds to a steam flow to the turbine of 760 t/hr) with an unchanging amount of opening of the first four regulating valve. The savings in conventional fuel amount to 7 g/KWH for a boiler steam load of 550 t/hr. The savings will be greater for gas-fuel oil boilers, which have a large control range. When the boiler operates as a single unit in conjunction with a PTN [feed turbopump], this economic savings will likewise increase. At the present time, an automatic system for regulating the heating unit for operation at fixed and "sliding" pressure is being introduced in the station No. 11 TETs-22 unit.

The use of supercritical steam parameters in a heating power unit boosts the requirements placed on the water mode and causes certain complications of the turbine installation configuration.

Despite the welding of the pipes to pipe plates in the mains preheaters of the turbine used by the UTMZ, a loss of seal at the joints is observed during operation. This leads to the intrusion of mains water into the turbine condensate.

To avoid the intrusion of degraded quality condensate into the feed water channel, it is fed beforehand to a block desalinization unit. Due to the low heat resistance of the ion exchangers, the condensate temperature should not exceed 40° C, and for this reason, it is cooled down in special coolers, in which case, the heat is lost in the circulating plant water. The amount of this loss reaches 12 GCal/h during midwinter operation.

For these reasons, it is economically advantageous to operate a power unit with the feed of the condensate of the mains preheaters into the main condensate line (into the PND [low pressure heater] cross-cut). At the present time, automated chemical monitoring of boiler condensate quality is being introduced, and the control of the slide valve is being automated for the execution of the apropriate switching.

A special feature of the configuration of the T-250/300-240 units is the fabrication of the piping systems of the condensate channel heat exhangers from stainless steel. Only the coolers of the main ejectors and the packing gland type preheaters on certain turbines are made of copper containing alloys. The condenser pipes are made of the MNZh alloy, and the high pressure preheaters are made of steel.

Operational experience with the units has shown that the traditional hydrazine-ammonia water mode permits maintaining the basic indicators in accordance with the PTE [technical operating regulations] standards.

For the purpose of introducing more refined water operational modes in the station No. 9 TETs-21 unit, since 1976, under the technical supervision of the All-Union Red Banner of Labor Heat Engineering Institute imeni F.E. Dzerzhinskiy, the efficiency of a neutral mode with the administration of hydrogen peroxide at the input to the booster pumps has been checked. The specific contamination of the NRCh [not further defined] of the boiler in this unit is half of that for a similar unit of this TETs operating in the hydrazine-ammonia mode. This is also confirmed by the results of measurements of the pipe metal temperature.

An inspection of the turbine showed that deposits were practically absent. Work on the mastery of the neutral mode with the administration of air is underway on the station No. 5 TETs-23 unit, under the supervision of the Experimental Scientific Research Institute imeni G.M. Krzhizhanovskiy.

For the purpose of further improving the water mode, copper containing alloys in the feed channel of the units are to be eliminated. For this, it is necessary to make the piping system of the ejector coolers out of stainless steel.

It is also proving to be expedient to dispense with steam-jet ejectors and to go over to water stream ejectors. The combined efforts of the plant, as well as operational, set-up, scientific research and repair organizations have made it possible to resolve a number of complicated engineering problems in a relatively short time, related to the mastering of the prototype high power heating equipment and to ahcieve specific results in its utilization.

The T-250/300-240 turbines are being placed on line with substantially fewer expenditures of time and money than for the introduction of units with the K-300-240 turbines. This is due to a certain extent to the utilization of the previously aquired experience, as well as to the high technical level of the engineering designs adopted in the development of this custom made plant.

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# SPECIFIC FEATURES OF THE T-250/300-240 TURBINES

Moscow ENERGETIK in Russian No 9, Sep 79 pp 4-6

[Article by V.Ye. Podberevnyy and P.D. Chernyayev, Engineers]

[Text] Heat and power supply occupies a special place in the development of domestic power engineering, based on the scale of which the Soviet Union is in first place in the world. In the USSR national economy, 55 percent of all of the fuel and power engineering resources being expended are used for the generation of electrical power and heat. The combined generation of electrical power and heat allows for a significant reduction in fuel consumption.

The rapid rise in residential construction, the fast pace of the expansion of old and the construction of new industrial enterprises have resulted in the creation of new superpower units for the first time in world practice with the T-250/300-240 heating and power generating turbine sets using supercritical steam parameters. The previously designed heat and power supply units with 50,000 and 100,000 KW turbines were not able to satisfy the demands of the rapidly expanding large cities, and became economically disadvantageous from the viewpoint of specific capital investments, labor expenditures for servicing, and were inferior in their engineering economic indicators in the condensation mode to the 300,000 KW units.

The collectives of the enterprises and organizations of the Ministry of Energy and the Ministry of Power Engineering Machines came up with a design in a short period of time for a superpower T-250/300-240 heat and power turbine using supercritical steam parameters with intermediate superheating, having a capacity of 250,000 KW in the heating mode and 300,000 KW in the condensation mode. The Urals Turboengine Plant has mastered the production of the high power T-250/300-240 turbines sets.

In terms of the engineering and economic indicators, and the structural design, the T-250/300-240 turbine meets modern requirements, is a very large heat and power supply turbine, which provides the advantage of the combined generation of electrical power and heat, as well as high operating economy because of the use of supercritical parameters and intermediate superheating of the steam.

The project plan and estimate documentation for heat and power supply units with the T-250/300-240 turbines was worked up for the first time by the Mosenergoproyekt [Moscow Power Engineering Planning Administration] Institute for the Moscow TETs [Central Heat and Electric Power Station].

The first unit with the prototype T-250 turbine installation was placed in service in 1971 at the TETs-22 of Mosenergo [Moscow Area Power Administration]. At the present time, eight such units with an overall heating capacity of 5,520 GCal/h have been installed and are successfully in service at the TETs-21, TETs-22 and TETs-23 of Mosenergo, something which have made it possible to supply heat to regions with a population of more than two million people.

The heat and power supply unit with the T-250/300-240 turbine includes the boiler with a steam productivity of 950 t/h (a TPP-210A or TGMP-314Ts), including a TVV-320-2 turbine with a generator and two peak hot water PTVM-180 boilers. The heat capacity of one unit amounts to 690 GCal/hr.

Some five T-250/300-240 units with TGMP-314Ts gas-fuel oil boilers, equipped with cyclones precombustion chambers, have been placed in service at the TETs-21 and TETs-23 of Mosenergo. A prototype of this boiler was installed at the TETs-21.

The Main Parameters of the T-250/300-240 Turbine

| | |
|---|---|
| Live Steam Flow Rate, t/h: | |
| Maximum | 980 |
| Nominal | 955 |
| Nominal Live Steam Parameters: | |
| Pressure, kgf/cm$^2$ | 240 |
| Temperature, °C | 540 |
| Parameters of the Steam Following Intermediate Superheating: | |
| Pressure, kgf/cm$^2$ | 37.5 |
| Temperature, °C | 540 |
| Turbine Power, MW: | |
| Nominal | 250 |
| Maximum | 300 |

| | |
|---|---|
| Nominal Heat Load, GCal/h | 330 |
| Flow Rate of Cooling Water to the Condenser, $m^3/h$ | 28,000 |
| Cooling Water Temperature, °C | 20 |

* * *

The basic heat circuit. The recovery system provides for reheating the feed water in high and low pressure preheaters with its deaeration in a 7 $kgf/cm^2$ deaerator.

The preheating of the mains water is accomplished sequentially in two horizontal main line preheaters, supplied with steam from lower and upper heating bleed lines of the turbine.

A prototype of the PTN-1100-350 feed turbopump of the "Ekonomayzer" plant was chosen for the feed water delivery.

Based on the operational reliability conditions for the unit, the feed pump was designed with a turbine drive, which provides for a capacity of 45-100 percent of the nominal.

The feed turbopump is rotated by a R-12-24-10 counterpressure turbine having a capacity of 12,000 KW, which is coupled to the bleed line of the main turbine at a nominal pressure of 24 $kgf/cm^2$.

The steam spent in the drive turbine at a pressure of 6.3 $kgf/cm^2$ is used for the internal requirements of the station, and a provision is made for the capability of returning it to the turbine. A scheme for starting the turbofeed pump from an external steam source was also developed in the Moscow Power Engineering Planning Administration, where this scheme provides for starting the unit with the turbopump.

The standby starting feed pump with electric drive provides for a unit load of 0 to 60 percent of the nominal. The power rating of the electric motor for the pump is 8,000 KW.

The productivity of the main feed pump is 1,000 $m^3/h$ at a pressure of 3,500 meters of water, and the productivity of the standby starting pump is 600 $m^3/h$ at a pressure head of 3,200 meters of water.

The requisite pressure head in the intake line of the feed pumps is provided by a group of three preliminary (booster) electric pumps in one unit. The output of each pump is 650 $m^3/h$ at a pressure head of 158 meters of water.

The starting scheme for the heat and power supply units with the T-250/300-240 turbines were worked out by the Moscow Power Engineering Planning

Administration in conjunction with the VTI [All-Union Red Banner of Labor Heat Engineering Institute imeni F.E. Dzerzhinskiy].

## The Main Engineering Design Solutions

The Production Process Section. The Moscow Power Engineering Project Planning Institute, in conjunction with the Urals Turboengine Plant and the All-Union Heat Engineering Institute imeni F.E. Dzerzhinskiy, as well as with the All-Union Scientific Research Institute for Water Engineering imeni B.Y. Vedeneyev executed the engineering and economic design of the cooling surface of the condenser and the irrigation area of the cooling tower. The optimal cooling surface of the condenser was taken as 14,000 $m^2$ and the irrigation area of the cooling tower was 3,200 $m^2$. A provision was made for 100 percent cleaning of the condensate, which is assured by the unit desalinization installation (VOU) with an output of 1,300 t/h.

The large volume of the high temperature condensate of the mains preheaters raises the temperature of the overall condensate flow entering the BOU above the permissible levels, inhibiting the operation of the ion exchange materials, and for this reason, it was necessary to pool the condensate. Two cooling schemes were considered, which were proposed by the institutes of the Moscow Power Engineering Planning Administration and the MO TEP [All-Union State Institute "Teploelektroproyekt" for the design and planning of thermal electric power plants]. The configuration designed by the Mosenergoproyekt Institute was selected following a detailed analysis.

The configuration provides for two-stage cooling of the condensate. The condensate of the mains preheaters is cooled by the desalinated condensate following the BOU, and thereafter, the mixture of the basic condensate and the condensate of the mains preheaters is additionally cooled by circulation or make-up water. This permits the utilization of 15 GCal/h of heat.

A provision is made in the production process configuration of the TETs for overall station desalinization and iron removal cleaning of the condensate, which permits the reduction of its losses to a minimum.

The reclaimation of the iron removal filters of the BOU is done remotely, and this reduces the use of acid resistant fittings and piping with anticorrosion coatings.

A fundamentally new scheme for chemical water purification with modular insertion of the filters was developed in the Mosenergoproyekt Institute. The principle of stepped counter-flow the cation and anion exchange filters was used in the design, something which also reduces the specific consumption of reagents for the reclaimation as well as the number of corrosive waste waters.

A provision have been made in the TETs's being planned for the installation of accumulator tanks with deaerated water for the make-up water for the heat network, something which has permitted a reduction in the chemical water purification output.

All of the contaminated waters of the TETs are completely cleaned, specifically: the waters remaining following chemical cleaning for reclamation, the flushing waters of the RVP [not further defined] and the peak boilers, as well as oil contaminated and fuel oil contaminated waters with their repeated utilization in the TETs cycle.

The increase in the thermal capacity of the heat supply sources permits an increase in the range of heat transmission which reaches 10 to 25 km at the present time. The diameter of the heating pipeline thorugh which the heat is removed from the TETs is 1,200-1,400 mm.

Automation, Protection and Remote Control. A system for centralized monitoring and control (STsKU) was designed for all units with the T-250/300-240 turbines.

Graphic control panels, with mnemonic maps of the production process configuration of the unit with mnemonic characters for monitoring and control, as well as with digital callup monitor meters, with permanently connected instruments and signaling displays, have been installed in the room for the control board of the unit. Remote control has also been provided for the most important cutoff and control valves (the manufacturing plant for the STsKU is the OZAP [not further defined] of Mosenergo).

An STsKU-M-6000 information computer complex designed around the M-6000 processor has been planned for TETs-21 and TETs-23.

An all-mode automatic control system based on GSP [not further defined] equipment has been developed for these same TETs's by the MO TsKTI and Mosenergoproyekt.

Production process protection has been developed and introduced for the heating and power supply units with the T-250/300-240 turbines for units with the TPP-210A pulverized coal boilers and the TGMP-314Ts gas-fuel oil boilers.

The Mosenergo SKB [special design office] of VTI in conjunction with Mosenergoproyekt designed an automated chemical monitoring circuit based on domestic instruments for the TETs-22.

Specific Features of the Layout of a Unit with the T-250/300-240 Turbine. In the design of the main frame, the universal modernized design for the main unit of a GRES with K-300 units, executed by TEP [All-Union State Institute "Teploelektroproyekt" for the design and planning of thermal electric power plants], was adopted as the basis.

It should be noted that for the first time, the plan calls for the placement of the T-250/300-240 turbine installation in a trubine room with a span of 45 meters, having a structural extension on the side of the row "A" columns 12 meters wide. However, engineering-economic calculations have shown that the variant of the turbine room with a single span of 54 meters is more economical. Because of this, for the first time in the Soviet Union, Mosenergoproyekt has developed a project design for the main building with a turbine room having a 54 meter span; the span of the deaerator area is 12 meters, the span of the boiler room is 39 meters and the distance between the centers of the unit has been taken as 60 m.

Besides the turbine installation, feed, condensate, and stage I pumps, as well as the BOU and condensate coolers have been placed in the turbine room.

The circulation pumps for the TETs-22 have also been placed in the turbine room, and at the TETs-21 and TETs-22, they are housed in the central pump room. The mains pumps of stage II have been installed in the boiler room. The deaerators for the feed water and the make-up water of the heating main have been installed in the deaerator room at the 21.6 meter marker. The unit and relay control panels, the cable ducts, the RU [not further defined] for internal requirements and other electrical engineering equipment have been placed at the lower markers.

An open space is located between the boiler room and the smokestack for the installation of the RVT [not further defined] and the draft machine. The peak hot water boiler room is placed after the smokestacks. A power generating boiler of the TPP-210A or TGMP-314Ts and two peak hot water boilers of the PTVM-180 type are connected to one smokestack (trunk), where the smokestack at TETs-23 is designed as a multiple branch unit type 250 meters high.

The Structural Section. The framework of the main TETs-22 structure is made of prefabricated, steel reinforced concrete, while the frames of the main bodies of the TETs-21 and TETs-22 are made of metal.

The primary problem which faced designers in the design of the structural section was to provide progressive design solutions which assure a reduction in materials and labor outlays on the construction site. The following solutions are of the greatest interest.

Economical standard prefabricated steel reinforced concrete foundations, developed by the LO TEP [Leningrad Branch of the All-Union State Institute "Teploelektroproyekt" for the design and planning of thermal electric power plants], the blueprints for which were revised by Mosenergoproyekt, taking into account the significant tensile stresses sustained in the upper regions of the foundations were adopted for the frame of the main body.

Prefabricated foundations were designed to go uner the PGMP-314Ts power boilers, as well as for the turbopumps with the upper metal grillwork.

A sand foundation was provided to replace the pile reinforced concrete foundation at the TETs-21 for the cooling tower with an irrigation area of 3,200 $m^2$.

The TETs-23, the salt warehouse and the central room for the circulation pumps were designed with prefabricated steel reinforced concrete elements.

Structures were developed which permit the installation of the heavy mains pumps directly on the basement roof, and not on separately standing foundations.

The flue gas extractor areas were made with pile foundations, which make it possible with the given soils to dispense with digging the foundations into a considerable depth beneath the heavy equipment.

Composite heated roofing panels of corrugated steel sheet were used to cover the main building.

Large glass windows of corrugated glass were developed to do the glazing of the turbine room. They are put together in an installation area and subsequently installed as large blocks.

Underground metal reservoirs with a supporting exterior wall of prefabricated concrete blocks were developed for the fuel oil reservoirs. The construction completely precludes leakage of the fuel oil.

Prefabricated steel reinforced concrete elements with a cross-section of 3 x 3 m were developed for the tunnels of the deep laid (down to 15 m) KZU [not further defined].

Alloy steels were widely used in the structural metal components.

Economy, Weight and Size. It is impossible to compare the T-250/300-240 turbine in terms of economy, weight and size with other heat and power turbines of the same power, since there are as yet no other such turbines. A comparison of the specific indicators for the T-250/300-240 turbine with the indicators of the T-100-130 heat and power turbine produced by the UTMZ shows that the major specific indicators of the T-250/300-240 turbine are better than for the T-100-130 turbine.

It should be noted that the results of tests performed by Soyuztekhenergo and published in the journal TEPLOENERGETIKA, No. 2 for 1977, confirmed the guaranteed data of the plant for the specific steam and heat flow rates. The main indicator which determines the economy of the turbine in heating and electrical power supply modes is the specificelectrical power output for the heat consumption.

The design calculations which have been performed demonstrated that one T-250/300-240 turbine, as compared to two T-100-130 turbines, permits an annual savings of conventional fuel of 40,000 tons.

The introduction of the T-250/300-240 units using supercritical steam parameters with intermediate superheating which was started in the Ninth Five-Year Plan in the heating and power systems will make it possible in the immediate future to substantially change the structure of the heating and power equipment of the TETs' to significantly improve heating and power supply efficiency and to achieve a savings in fuel.

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## BRIEFS

**NEW HIGH-VOLTAGE TRANSFORMER DEVELOPED**--Power transformers of a new voltage class are being developed by the collective of the All-Union Institute of Transformer Building in Zaporozh'ye. A high government award--the Order of the Friendship of Peoples--has been presented to the institute for developing and introducing transformer equipment for a 750-kilovolt power transmission line. The equipment has been installed on the Vinnitsa-Albertirsa power transmission line. [Text] [Moscow IZVESTIYA in Russian 22 Nov 79 p 2]

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FISHERIES

## WORKING CAPITAL PROBLEMS IN FISHING INDUSTRY REVIEWED

Moscow EKONOMICHESKAYA GAZETA in Russian No 50, Dec 79 p 18

[Article by Ye. Galova, economist: "How Profit is 'Dissipated'"]

[Text] In the operations of the associations and enterprises, great concern is being shown for fulfilling the quota for the growth of profit as this under the new conditions is one of the basic planned and evaluation indicators in the five-year and annual plans.

The ways for increasing profit certainly are not limited to mobilizing reserves in the area of just production activities. From the example of the enterprises of the USSR Minrybkhoz [Ministry of Fish Industry], it is possible to analyze how important here is a reduction in the unproductive and unplanned expenditures which at times "consume" what has been provided from production operations. The disclosure and elimination of these shortcomings are one of the effective factors for a rise in profit.

In 1978, at the enterprises of the USSR Minrybkhoz, actual profits from production operations were 653.7 million rubles with a plan of 597.6 million rubles. However the various sorts of expenditures made from profits were above the established planned expenditures and exceeded the total obtained profits by 41.2 million rubles. In particular, expenditures on the running of the housing and utility system and the payment of interest for bank credits were above the plan. Penalties paid for the nondelivery of products and for violating the cargo shipping conditions were almost 25 million rubles, and 28 percent of the associations and enterprises last year did not fulfill the profit quotas and produced above-planned losses of 56.5 million rubles, nullifying the results of the remaining enterprises which significantly overfulfilled the plan for the financial indicators.

The presence of a large number of enterprises which committed an exceeding of expenditures made from profits above the planned amount and the significant unrealized losses were the reason for the major shortage of own working capital as a whole for the ministry. Thus, according to the summary balance for all the Union republic enterprises in the fishing industry, the lack of own working capital by the end of 1978 was 61 million rubles in comparison with the established rates. A loan from the USSR Gosbank was provided to cover the shortage of working capital.

One of the ways for improving the financial and economic activities is to accelerate the turnover rate of working capital. The Basic Directions for the Development of the USSR National Economy in 1976-1980 provided that the turnover rate of working capital during these years would be accelerated by an average of 3-5 days, or approximately by 5.5 percent of the inventories which existed at the start of the Tenth Five-Year Plan. For the enterprises in the fishing industry, with its relatively high carryovers of normed working capital in comparison with the industrial average, goals were set of increasing the turnover rate of working capital up to 5.0-5.5 days during the 5-year period.

However these quotas were not met. With the speed-up in the turnover rate of working capital of 2.6 days planned for 1978, the turnover of assets slowed down by 3.7 days. As a result of this more than 88 million rubles were "frozen." Another reserve is a reduction in the above-normed uncredited commodity inventories. In this regard, all is not well for individual industrial enterprises of the USSR Minrybkhoz. In 1978, these inventories were 5.5 percent of all the inventories in comparison with 4.8 percent at the start of the previous year.

As a whole, over the 3 years of the five-year plan, the balances of normed working assets at the enterprises of the fishing industry rose by 18.6 percent, with a growth of 11.4 percent for expenditures on producing the products.

Under the conditions of the balancing of the planning indicators and more accurate planning and extending of the range of the physical indicators, above-norm inventories are inacceptable. The formation of them must be viewed as miscalculations in the production operations of the enterprises and even now the causes of them must be analyzed in detail in order to prevent their appearance in the future.

An analysis of the structure of the balances of normed working capital has shown that the highest growth of the balances of material commodities was allowed for production inventories, incomplete production and finished products.

While within production inventories the balances of raw products and basic materials rose by 12.2 million rubles or by 6 percent over the 3 years, the inventories of auxiliary materials over the same period increased by 48.3 million rubles, and this means a growth of 21 percent.

The balances of spare parts increased even more for repairing the fixed productive capital. In 1976-1978, their volume increased by 26.8 percent, while the volume of repairs during these years increased by only 12.6 percent. Stocks of inexpensive and rapidly replaced articles at the warehouses and in operation also increased by more than 30 million rubles, or by almost 12 percent. The working assets invested in incomplete production also rose.

Many enterprises of the USSR Minrybkhoz do not fulfill their obligations for product deliveries. Under the new conditions, when an economic evaluation of the activities of the associations and enterprises is made primarily proceeding from the fulfillment of the delivery plans in terms of range and established dates, such a phenomenon is simply intolerable.

As analysis shows, in the ministry control has not been organized with sufficient efficiency over product sales, and this has contributed to a rise in the balances of finished products at enterprises warehouses. In 1975, the balances of unshipped finished products were 16.3 days, and in 1978 these had increased up to 20.4 days, or by 25 percent.

All of this has led to a general significant slowdown in the turnover rate of working assets in the fishing industry.

The rational utilization of working capital should be achieved on the basis of observing the established standards calculated by the enterprises and associations considering the rise in the production volume and the acceleration of the working capital turnover rate. The search for reserves should be directed at making certain that for each ruble of working capital the fishing sector receives more product for satisfying the growing needs of the people. For these purposes we feel it is essential over the short run to settle the question of including an indicator for the turnover rate of working capital as part of the economic indicators which would describe the overall result of the economic and financial operations of the associations and enterprises.

The better utilization of material and financial resources in circulation and the systematizing of credit and payment work in the associations and enterprises will make it possible to raise their profitability and strengthen their financial position.

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## FUELS AND RELATED EQUIPMENT

### KANSK-ACHINSK FUEL-ELECTRIC POWER COMPLEX DISCUSSED

Moscow SOVETSKAYA ROSSIYA in Russian 2 Nov 79 p 2

[Article by Ye. Komarskikh and Yu. Popov, SOVETSKAYA ROSSIYA special correspondents, Sharypovo settlement, Krasnodarskiy Kray: "The KATEK Program, Letters Concerning the Development of the New Fuel-Electric Power Complex"]

[Text] When the Ministry of Power and Electrification began the formation of a construction organization on the KATEK [Kansk-Achinsk Fuel-Electric Power Complex] site, there arose the following question: directing personnel of what "rank" of organizations, what qualifications and of what competence were to be placed in charge of affairs there?

Those of an organization no lower than a trust, as it turned out, based on both the volumes of operations to be accomplished and the example offered by the project for the construction of the same kind of electric power facility in Ekibastuz. But as things then stood, current operations provided for organization and recruitment for only the typical, ordinary construction administration, which, according to current statutes, would not have the authority to create the required divisions and services. So in order to justify a "signboard" corresponding at least to some extent to the tasks involved in the construction project to be undertaken, the new trust was reorganized so as to include three more administrations, which were then engaged in operations at sites having no connection whatsoever with the complex, and were furthermore located at points far removed--in Nazarovo, Achinsk and even Kyzyl--from the production facility to be constructed.

It goes without saying, of course, that each of the facilities "attached" to KATEKenergostroy is important in itself. But like it or not, they are every now and then responsible for the diversion of manpower, resources and the attention of adminstrative services away from the site which has given its name to the newly created organization, which has already today become an exceedingly expensive operation--the current annual program calls for an expenditure of 21 million rubles--and according to even the most optimistic estimates it is only one-third completed. And in the future as well, the volumes of operations carried out by the power facility construction workers alone will be reckoned in the tens of millions of rubles annually.

Minugleprom [Ministry of the Coal Industry] organizations anticipate operations on no smaller a scale. But this ministry as well has so far failed to concentrate its energies on the most important projects, on which depends any acceleration of preparations for bringing the main open pit into operation. The project here has at least been made the responsibility of an organization somewhat more solid and reliable than a trust--but this difference has so far been reflected not so much in the scope of the operations involved, but rather in the tendency which has been shown toward interdepartmental "migration." Despite a gentlemen's agreement between the two general contractors not to attempt to lure one another's cadres away, KATEKenergostroy specialists have already begun to make visits of inquiry to the KATEKuglestroy office....

All of these complex and confused situations have arisen in consequence of a lack of regulation and control within the TPK [territorial production complex] administrative system. It is indeed the case that Minenergo [Ministry of Power and Electrification] and Minugleprom have now created special all-Union associations for the construction of these very fuel and power complexes, that is, the Ekibastuzskiy, the Yuzhno-Yakutskiy and the Kansko-Achinskiy fuel and power complexes. They are attempting ever more vigorously to exert their influence on current operations at these construction sites. But this administrative echelon is also a component of a "vertical" system. We may assume that it will prove rather difficult to coordinate "horizontal," territorial lines of authority with those within an industry organization however well-organized the system may be. Even today, meanwhile, problems are still awaiting resolution which reach far beyond the frame of reference of the industries. It would be difficult to postpone dealing with any of them until a distant future. Each of them has its origin in developments unfolding at the construction site itself and in decisions made by central and industrial authorities; each is, practically speaking, inseparable from the other; and each requires large-scale economic-administrative operations, close mutual ties and clear-cut, effective coordination on a daily basis.

This region of Siberia appears from a bird's-eye view as a boundless, continuous field, whose vast expanses stretching for kilometers now yellow with the stubble of harvested wheat, now darken with the plowed fields prepared for the next sowing. But such is the dialectic of these transformations that under the great pressure exerted by the steel earth-moving equipment, a bed of coal has been exposed which is so indispensable to electrification that...the arable land recedes.

And this coming just now when we have an immediate need for the use of this land; for thousands and thousands of people will be settling here in the immediate future. How are we to resolve this contradiction which was so clearly revealed with the first open pit? For thousands of hectares of land can disappear with even relatively insignificant, as compared, that is, with other open-cut operations, amounts of rock removed for pits and banks.

Scientists and specialists with the branches of industry now establishing themselves here are striving to provide for all environmental protection measures now practicable. Coal mining technology now involves provision for the reclamation of land disturbed in the course of mining operations by filling in the open pits with the rock stripped off and the recultivation of the soil.... This has been planned rationally. But this clear decision leaves questions occasioning more thought. Do we really have to wait while one open pit or another is working and then filled in...couldn't we more wisely immediately utilize the chernozem stripped off for adding to the layer of soil on arable land which now has poor soil? This suggestion comes from the rayon party and soviet organizations, which for dozens of years have dealt with none other than agricultural concerns. The coal-extraction and soil-recultivation technology have been developed by Minugleprom institutes, which have long since been oriented solely toward the depths of the earth. But who is competent to make a decision?

And the ash dumps?

The Berezovskaya GRES No 1 alone will be burning an enormous amount of fuel each day. With even the local coal's minimum ash content, entire heaps of slag and ash will be produced as waste each day; while with the latest electrofilters, clouds of smoke are still being given off into the air.

Scientists are already working on the development of a system of waste-free processing of Kansk-Achinsk coal. The possibility of preventing environmental pollution by chemicals and ash is theoretically well-founded: tests have already been conducted on processes in which the gases and solid substances contained in the coal are utilized in the production of synthetic liquid fuel, as well as of sulfuric acid and other valuable chemical products. What we are speaking of here are great high-capacity chemical-power complexes, which will produce not only electric power, but also gasoline, diesel fuel and the most valuable construction materials and at the same time will preserve the air and water basins and almost completely utilize all wastes.

This is by no means a thing of the far distant future. Experimental facilities designed for use in the development of improved processes utilizing Kansk-Achinsk coal are now under construction in Krasnoyarsk and Novosibirsk. But the construction of these facilities is moving at a pace far behind that called for by the approved schedules. Still more uncertain remains the matter of the utilization of wastes for the production of construction materials, despite the fact that scientific recommendations have been put forward in this area as well: production of agglomerated powder gravel and porous filler material from ash waste is entirely practicable. In the meantime, however, the industry which should above all have demonstrated an interest in these ideas, the construction materials industry, has so far remained on the sidelines in this research effort.

Let us now return to the subject with which we began, the providing earth. Local party and soviet authorities are devoting the most constant attention to this problem. The allocation of every piece of productive land undergoes the closest expert review, serious modifications in original proposals often being made in the course of this study. To preserve arable land in the area of the construction project, for example, changes were made in previously planned rail and highway routes.

A special commission has been set up in the kray which is participating in the development of a detailed program of economic specialization and of the creation of agroindustrial complexes within the Sharypovo industrial center and a number of other adjacent rayons. Plans call in particular for a 1 1/2- to 2-fold increase in the production of meat, milk and eggs and even greater increases in that of potatoes and vegetables.

Much has been done to see that new KATEK settlers live well. But how now can we realize these well-laid plans more quickly in the form of concrete accomplishments?

All production facilities in Sharpovskiy Rayon are anticipating specialization. One of them, the Orakskiy sovkhoz, has been earmarked for the selection of meat production as a specialization. Plans call for organizing the fattening here of 9000 head of horned cattle. But draft plans are early on coming into conflict with current production tasks. Still retained for the sovkhoz are its dairy herd and its pig- and sheep-raising and other operations.

"But if we're going to specialize in fattening cattle, we've got to do it in practice and not simply on paper," declared A.I. Kozhura, the sovkhoz director. "Otherwise we will remain a meat-and-dairy, bristle-and-sheepskin-producing state grain farm. What we also need now is an immediate reexamination of our arable utilization structure with a view to strengthening our feed base and more mineral fertilizers. But the main thing,"--at this point the director switched back to a subject which had been raised again and again in the course of our entire trip--"the main thing, just as is the case in the city, is that we have above all to resolve the social problems."

The complex is raising a complex set of problems. Accomplishment of the specific program for its development will require a full mobilization of resources, a concentration of effort and what is most important, the productive utilization of both. But is a mobilization like this possible in the absence of a centralized administration in possession of a system of efficient and effective controls?

A whole series of scientific institutions is now engaged in the development of proposals concerning possible forms of administrative for a complex like KATEK. While their approach to the problem is not always identical, it is worthwhile for Gosplan USSR and other central authorities to listen to their views.

In discussing his division's work in drawing up grid charts for the construction of KATEK facilities, including the Berezovskaya GRES and open-pit coal operation, E.A. Burov, director of the Krasnoyarsk Economic Research Division of the Institute of Economics and the Organization of Industrial Production of the Siberian Department of the Academy of Sciences of the USSR, directed our attention to the difficulties involved in this effort resulting from the absence of any clear-cut, mutually coordinated program of construction of facilities under the jurisdiction of different ministries.

"What we need now is a state plan for the entire complex, one approved right down to the matter of titles," he declared. "In executing this plan it would be important to increase the role played by local soviet authorities. How? Experience shows that if highly qualified specialists were to be added to the kray planning commission and the krayispolkom's capital construction section, and if the requisite services were established there, they could to a great extent assume responsibility for that coordination of construction operations within the TPK which has so far been exercised by kray organizations of the basis, so to speak, of their own initiative.

In the view of specialists of the All-Union Scientific Research Institute for Systems Research, on the other hand, it is precisely the Kansk-Achinsk fuel and power complex that can become an example for the formation of territorial economic associations on the basis of shared participation and their cooperative administration by the ministries concerned.

"The controlling administrative body on the site, which would include representatives of the ministries and departments involved in the construction project, might head up this financially autonomous association," explained the institute's deputy director, Doctor of Economic Sciences B.Z. Mil'ner. "This body would solve the basic problems: where, for example, should efforts be primarily concentrated--on the creation of an infrastructure, cadre training--and direct the day-to-day operations of the organizations participating in the construction project."

As we can see, there is a variety of alternatives. But one thing is clear: the course of developments at this, one of the largest construction sites, urgently requires improvement in the system of administration.

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## WORK OF UKRAINIAN NATURAL GAS INSTITUTE REVIEWED

Kiev NEFTYANAYA I GAZOVAYA PROMYSHLENNOST' in Russian No 3, Jul-Sep 79 pp 1-4

[Article by V.F. Budymka, director of the UkrNIIgaz Institute: "20 Years For UkrNIIgaz"]

[Text] In 1959 a branch of the All-Union Scientific Research Institute of Natural Gases was created in the Ukraine. In 1965 the branch was reorganized into the Ukrainian Scientific Research Institute of Natural Gases and became one of the leading scientific institutions in the field of prospecting and developing gas and gas-condensate deposits, in the extraction, preparation, transport and underground storage of natural gases on the territory of the Ukraine, Belorussia, Moldavia and the Baltic Soviet republics.

In subsequent years the Soyuzturbogaz All-Union Production Association (VNPO) and the Ukrainian branch of VNIPIASUgazprom, reorganized in 1979 as the NIPITransgaz Institute, were organized on the basis of UkrNIIgaz.

In 20 years UkrNIIgaz has completed a significant amount of work, as the executor and co-executor of topics according to the coordination plan of the State Committee for Science and Technology and the assignments of the Ministry of the Gas Industry and the Ukrgazprom All-Union Production Association. Many topics were decided on the level of inventions which are widely used in the republic's gas industry and other gas-extracting regions of the country.

An important place in the institute's work has been occupied by the General Scheme of Geological Prospecting for Gas and Setting Up Prospecting Regions of the Ukrainian SSR, prepared jointly with the Ukrainian SSR Ministry of Geology. Basic regularities of the placement of accumulations of gas in the earth were revealed on the basis of detailed analysis of the status of geological prospecting. Maps were made of the oil and gas geological zoning of the territory of the Ukrainian SSR, and changes in rock-collectors in the epigenesis on sections of 3,000, 4,000, 5,000 and 6,000 meters of the Dnepr-Donets depression.

The geological basis of development of resources and extraction of gas up to the year 2000 has been developed and introduced for the Ukraine, and every year recommendations are being developed regarding the directions of geological prospecting for gas in the promising basins of the Ukraine, Belorussia, and Moldavia, and in the water areas of the Black and Azov seas.

The drilling of exploratory and test wells is done according to plans compiled by the institute. Plans have been worked out for testing Devonian and lower-carboniferous deposits of the Mikhaylov section, the stock zones of the Krestishchenskoye, Melikhovskoye and Runovshchinskoye deposits, the subsalt $(P_1-C_3)$ terrigenous formations of the Mashevskoye and Melikhovskoye deposits, the chemogenous Permian layer of the Krestishchenskoye and Melikhovskoye deposits, Mesozoic layers of the Ugerskoye and many others.

Every year proposals are worked out for the plans of geological prospecting for gas with the aim of the fastest possible supplying of raw material bases of gas extracting enterprises of the Ukrgazprom All-Union Production Association.

Recommendations have already been issued on more than 50 sites of the Dnepr-Donets depression, for 30 sites of the Carpathian depression and southern regions of the Ukraine. Opened as a result were the Timofeyevskoye, Gadyachskoye, Raspashnovskoye, Chutovskoye, Kotelevskoye, Yuzhno-Oparskoye, Kalinovskoye, and Tat'yanovskoye gas deposits.

Drilling has been widely developed. Albums are being compiled of the well designs of the Ukrgazprom All-Union Production Association reflecting the mining and geological conditions of their drilling and designs, the compositions of the flushing fluid according to drilling intervals, the formulas of their treatment and so on.

Instructions and recommendations have been issued to drilling enterprises on the prevention and elimination of accidents and complications when driving the wells. The technical documentation and instructions have been worked out for introduction of outside pipe grabs of increased lifting capacity which have been manufactured and tested under field conditions.

A unit for destroying persistent foams has been created and tested.

Recommendations for cutting super-deep wells of 500, 600, and 700 were developed for the Shebelinskaya site. Tested for the first time in the Soviet Union were compounds on the basis of the MFS-0.1 resin for reinforcing the face zones of gas wells.

Developed for the purpose of preventing gas phenomena were degasifiers and placement schemes for drilling equipment to prevent and eliminate active gas phenomena. More than 80 degasifiers were introduced in the oil and gas extracting regions of the USSR and abroad.

Studies have been made and more than 130 plans have been compiled for development, experimental operation and adjustments to them, the introduction of which made it possible to put into operation early the majority of gas and gas-condensate deposits in the Ukraine.

In accordance with the planning decisions carried out at the new sites in condensed periods in a single technological cycle were operations for final prospecting, calculation and confirmation of the reserves of gas, for setting up the fields and accelerated introduction of the development of new deposits. As a result the times for development of many new deposits in the Ukraine were reduced on the average from 6 to 1.5-3 years. The final prospecting performed in the process of OPE [not further identified] made it possible reliably to substantiate and to transfer to higher categories (A+B) the gas reserves of the Kegichevskoye, Borovskoye, Mashevskoye, Yefremovskoye, Lannovskoye, Vergunskoye and other deposits. The additional increase in gas extraction at the new deposits made it possible to stabilize the extraction of gas in the Ukraine. Measures to increase the gas yield were conducted, for instance, at the Proletarskoye, Pynyanskoye, Khodnovichskoye, Borovskoye, Vergunskoye, Shebelinskoye and Pereshchepinskoye deposits.

Used for intensification of gas extraction were acid treatments and flushing of face zones with acidic foams, hydraulic sandblasting perforation, reinforcement of face zones with filters and synthetic resins and other methods.

UkrNIIgaz jointly with the Ukrgazprom production organizations is conducting work to combat corrosion of metal fittings, structural elements and parts.

The institute has proposed the use of nitrogen-containing compounds as a corrosion inhibitor. These compounds make it possible to obtain effective protection of the equipment under carbon dioxide conditions.

The ANPO [not further identified] inhibitor was used at 12 wells of the Oposhnyanskoye and Gadyachskoye deposits with an economic effect amounting to 620,000 rubles.

The institute maintains business relations with many scientific and production organizations regarding questions of anti-corrosion equipment. Joint projects are being carried out with the departments of electrochemistry and general chemistry of the Khar'kov Polytechnic Institute, the Dneprodzerzhinsk Industrial Institute, the Khar'kov Aviation Institute, VNIIPAV [not further identified], the Shebekino and Dneprodzerzhinsk chemical combines and others.

The area of field preparation of gas for long-distance transport through trunk gas pipelines has received significant development in the institute. Methods have been developed for control of the process of low-temperature separation of gas, and for analysis of the quality of the treated gas and the quality of hydrate-formation inhibitors. The OPD-3 device was created for measurement of the dispersion of the liquid phase in high-pressure gas flows without violation of its structure. The "Sigma-2" device was developed for measuring the coefficient of surface tension at the liquid-gas interface at high pressures. The manufacture and introduction of experimental industrial apparatus for gas pretreatment at enterprises of the gas industry of the Ukraine and the RSFSR were organized.

Put into operation at the Krestishchenskoye deposit was the UKPG-5 [not further identified], equipped with highly effective technological apparatus, recommended by UkrNIIgaz.

The SViK-60 device for spectral vibration control and a method of rapid evaluation of the technical status of gas-turbine units (GTU), making it possible to raise significantly the level of operation and conduct of repair jobs were adopted for industrial use at enterprises of the Ukrgazprom All-Union Production Association.

The Ugerskoye, Oparskoye, Dashavskoye, Olishevskoye, Chervono-Partizanskoye and Krasnopopovskoye underground gas storage facilities were set up according to the plans of UkrNIIgaz.

Technological and technico-economic substantiation of the work of a group of gas deposits in the regime of underground gas storage facilities was conducted for the first time in the USSR. Technological recommendations and measures are being implemented for the creation of a large complex of underground gas storage facilities on the basis of the Ugerskoye, Dashavskoye and Oparskoye depleted gas deposits.

Measures developed by the institute in the field of economics have allowed Ukrgazprom enterprises to improve the system of planning and economic incentives, and to increase their interest in attaining the most productive results with the smallest outlays of capital investments and physical resources.

During the years of the 10th Five-Year Plan a significant number of institute projects was introduced, defended by author's certificates.

We should note the following from among the projects created in the institute and introduced at industrial enterprises of the gas sector with a large economic benefit:

A unit for simultaneous determination of the temperatures of the dew point and the start of hydrate-formation in gases--the "Khar'kov" device (authors M.F. Tkachenko, A.I. Derkach, V.Ya. Klishchenko and others);

A well filter (authors G.V. Timashev and O. Zh. Kalnin). Equipped with these filters, in addition to a number of deposits in the Ukraine, are three Kettsin underground gas storage wells in the GDR and wells of the Zelenche deposit in the Polish People's Republic;

A vacuum degasifier of the DVS-II type (modernized DVS-III) (authors N.I. Degtev, and A.I. Zinkevich). According to its parameters it is superior to the degasifiers of an American firm that are widely used in foreign practice. The UkrNIIgaz designed degasifier is being supplied to 14 countries in the world. The annual national economic benefit from use of the degasifiers in industry comes to 30 million rubles.

Beginning with 1966, three institute projects have been patented, for which 12 patents of different countries have been obtained.

Innovations with the brand name of UkrNIIgaz are regularly shown at the All-Union Exhibit of National Economic Achievements of the USSR and the Ukrainian SSR, and at international, intersector and sector exhibits. In the period from 1970-1979 alone UkrNIIgaz developments received 3 gold medals, 24 silver and 63 bronze medals, and many certificates and prizes.

The FSP-2 well filter developed in the institute was presented at the "Inveks-78" international exhibition in Brno.

Many developments from UkrNIIgaz will be exhibited in 1979 in the main exposition of the Gas Industry pavilion at the All-Union Exhibit of National Economic Achievements of the USSR.

The institute annually issues jointly with VNIIEgazprom [All-Union Scientific Research Institute of Economics of the Gas Industry] collections of scientific works "Geology and Development of Gas and Gas Condensate Deposits of the Ukraine," and monographs, dozens of instructions, recommendations, and manuals, and publishes more than 100 scientific articles in sector journals, and summaries of reports at scientific conferences.

In the institute a large data fund has been set up and is systematically replenished, and the forms of data services for laboratories, divisions, and kindred scientific and production organizations are being expanded.

The institute's collective is directing its knowledge, energy and initiative to early fulfillment of the decisions of the 25th CPSU Congress and the tasks of the 10th Five-Year Plan.

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## LAYING OF SURGUT-POLOTSK OIL PIPELINE DESCRIBED

Moscow IZVESTIYA in Russian 28 Nov 79 p 6

[Article by B. L'vov, correspondent of the Minneftegazstroy press center: "An Oil Pipeline Spans the Volga, An On-the-Scene Report"]

[Text] Work on the middle section of the Surgut-Polotsk oil pipeline is now moving ahead at full speed. The "construction site" for the line stretches for almost a thousand kilometers--from Perm' to Gor'kiy.

Many thousands of tons of fuel have already been refined from the Siberian oil flowing several months ago from the northern Ob' region to Perm' along the giant pipeline being laid by Minneftegazstroy [Ministry of Construction of Petroleum and Gas Industry Enterprises] construction personnel. Construction and fitting operations are now proceeding at full pace on the next section.

Another 818 kilometers of the main underground pipeline are being readied to be turned over for operation. A large part of the pipe here has been welded and insulated. Construction of the pumping stations is now under way. More construction is in progress at the Samotlorskoye, Fedorovskoye, Kholmogorskoye and other sites in the northern Ob' region whose oil is carried by the pipeline.

Working at shock pace on the enormous construction site, which stretches from the central Urals to the Volga are personnel from organizations representing Glavvostoktruboprovodstroy [Main Administration of Eastern Regional Oil Pipeline and Pipe System Construction], Glavtruboprovodstroy [Main Administration of Oil Pipeline and Pipe System Construction], Soyuzgazpromstroy [All-Union Association of the Ministry of Constfuction of Petroleum and Gas Industry Enterprises] and other organizations.

A day or so ago, construction personnel from the Soyuzpodvodgazstroy trust reported their latest labor victory: the laying of a 1 and 1/2 kilometer fuel bridge across the Volga. It runs across the river bottom and now provides a supply of Siberian oil to the central part of the country.

The underwater construction workers had no easy time of it. Extraordinarily prolonged spring and fall flooding and an early onset of cool weather compounded their difficulties. Divers spent hundreds of hours underwater, frequently having to make their way through slush ice and perform their tasks by touch.

A troublesome situation also confronted construction crews in laying the line across the floodplain as well. Rains turned it into a difficult stretch of viscous mud. Primary welding and assembly operations were nevertheless accomplished right on the riverbank itself. The enormous length of pipe was assembled here into a single continuous line and then towed from one bank to the other. Providing models of selfsacrificing labor under these conditions was N. Fadeyev's combined crew. It accomplished all operations in preparation for towing the siphon. Also turning in outstanding performances were the pipe-layer operator N. Boin and V. Gerasimov, who operated the hydraulic dredge which prepared the pipeline's bed on the river bottom.

"The completion of the work on the Volga crossing," declared A. Khar'ko, Minneftegazstroy's chief traffic control officer, "is not only a great production and operational success; it is a serious test for the future as well. For the Surgut-Polotsk pipeline construction crews have still to cross this great Russian river two more times--in Yaroslavskaya and Kalininskaya Oblasts. But we can say with all confidence that they are prepared for this great undertaking."

Construction workers from the western stretch of the line have also joined in competition for the most rapid completion of the entire project from Surgut to Polotsk. Advancing from Gor'kiy are construction and assembly columns of a component of the Lengazspetsstroy trust. The first kilometers of sections of the line have already been welded in Kalininskaya Oblast. Construction crews are now preparing to cross over into Belorussian territory.

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FUELS AND RELATED EQUIPMENT

## ANTI-CORROSION STUDIES ON EXPERIMENTAL PIPELINE DESCRIBED

Moscow PRAVDA in Russian 20 Nov 79 p 3

[Article: "Laboratory Pipeline"]

[Text] A 3-kilometer pipeline laid in the Samotlor oilfield is helping to arrive at methods of fighting corrosion. The laboratory pipeline is equipped with monitoring and measuring devices and other instruments.

Hundreds of kilometers of pipe are laid each year in the Tyumen' oil fields. But from time to time some of them fail and go out of operation. Studies have shown that this is most often the result of corrosion. The first important results have already been obtained on the experimental pipeline. It has been proven that the "survivability" of the metal can be enhanced by modifying the hydrodynamic oil-flow regimes.

This unusual laboratory has become well-known far beyond the borders of Tyumenskaya Oblast. In addition to the Tyumen' people, one might meet here specialists from research institutes in Moscow, Tatariya, Bashkiriya, Krasnodar or Grozniy. They are in the process of jointly developing a comprehensive program of research on protecting oil pipelines against corrosion.

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## FUELS AND RELATED EQUIPMENT

### GROZNIY OIL REFINERY MODERNIZATION DESCRIBED

Moscow IZVESTIYA in Russian 20 Nov 79 p 1

[Article by IZVESTIYA correspondent A. Kazikanov and GROZNENSKIY RABOCHIY correspondent G. Levin: "Refinery Modernized"]

[Text] A special purpose ELOU-AVT unit has been put into service two months ahead of schedule at the Grozniy Oil Refinery imeni Lenin.

The city's oil refineries produce millions of tons of various types and grades of fuel and oil. An extensive modernization program has now been launched in the Grozniy refineries built as long ago as before the war. An electrodesalinization unit constructed in combination with an atmospheric vacuum pipe still (ELOU-AVT) is one of the first large facilities involved in this thoroughgoing modernization.

"Checheno-Ingushetiya had had no experience in the rapid construction of facilities like this," declared L. Magomadov, secretary of the CPSU obkom. "But the people had an enormous desire to accomplish this critical task successfully. Construction operations began to move at an intensive pace. After concluding an agreement on the basis of 'working competition,' the construction crews of Yu. Nikishin, A. Maashev and I. Bagayev and the assembly and installation teams of D. Babochenko, N. Shutov and M. Anan'yev overfulfilled their plans."

Within a brief period of time, two years and ten months, funds had been expended to the tune of approximately 42 million rubles and more than 15 thousand tons of metal construction and production apparatus and equipment assembled and installed.

"One ELOU-AVT will replace several old units in operation at the Lenin refinery," explained G. Yatsenko, general director of the Groznefteorgsintez association. "The new unit will make it possible almost to double labor productivity and to reduce the number of personnel by 80."

The first to go on duty in the new facility were the work shifts of the leading operator, Nikolay Aleynikov. The automatic equipment was switched on. And then after the prescribed period of time, the instruments indicated that the unit had achieved its normal production operational parameters and that within the ELOU-AVT there had begun the reactions involved in the breaking down of the petroleum into its various components. The sampler Ol'ga Arbuzova removes a test tube with the first grams of gasoline. It's a product for the market!

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## BRIEFS

TURKMENIAN REFINERY--Turkmen SSR--The pace is picking up on the construction of the Chardzhou oil refinery, the largest in the republic, which is being built in accordance with the decisions of the 25th Congress of the CPSU. The foundation has now been laid for the main production facility, and installation operations and work on the assembly of the large pieces of equipment are under way. Working in addition to Soviet workers on the construction project are specialists from the GDR [German Democratic Republic]. They are supervising assembly and installation of equipment for the ELOU-AVT atmospheric vacuum and desalinization unit supplied by the German Democratic Republic's Grimm machine-building association. The Chardzhou refinery will become an important supplier of many types of fuel for the national economy. It will refine both Turkmenian and Western Siberian oil coming in by pipeline. The first stage of the project, which is now under construction, is intended to refine several million tons of the "black gold" annually. [Text] [Tallin SOVETSKAYA ESTONIA in Russian 4 Oct 79 p 1] 8963

UZBEK CONDENSED GAS DEPOSITS--Tashkent--The Zevarda condensed gas deposit in southern Uzbekistan has been brought into production. This underground store will be able to send millions of cubic meters of fuel a day into the pipelines. Since the beginning of the five-year plan, republic geologists have discovered seven gas deposits, in the process exceeding the five-year target for increasing reserves of this precious raw material. [Text] [Moscow TRUD in Russian 23 Nov 79 p 1] 8963

AUTOMATED OIL-FIELD CONTROL SYSTEM--Chardzhou--The automated "Signal-3" system has now taken over control of the operation of more than 40 wells and a variety of production installations separated from one another by an average of up to 10 kilometers. It has been brought into service in the Kirpichlinskiy field, which supplies up to 25 million cubic meters of gas a day to the Central Asia-Center pipeline. [Text] [Moscow IZVESTIYA in Russian 23 Nov 79 p 2] 8963

NEW DONBASS PRODUCTION OPERATION--Lisichansk-Severodonetsk--The industrial Donbass has discovered yet another advanced specialization. Siberian oil has already begun to be converted here into gasoline, diesel fuel, oil and the raw material which provides the basis for the manufacture of plastics, solvents, varnishes and lacquers, fibers, industrial alcohol and herbicides for agriculture. The Lisichansk oil refinery is a creation of the Tenth Five-Year Plan. Its mazut and diesel fuel have been certified as first-category products; and now its primary product, directly distilled gasoline, has also been awarded the government's Seal of Quality. And now, the new ELOU-AVT primary oil refining facility has been brought into service at this refinery. A polyethylene production complex, one of the largest within the domestic chemical industry has simultaneously been brought into operation nearby in the Azot association in Severodonetsk. This unique "tandem" has tasks to perform in common. From Lisichanski a 36-kilometer pipeline carries gaseous ethylene to Severodonetsk where it is converted into polyethelene. Severodonetsk chemists will now be producing 18 types of polyethylene. Azot's firm trademark, a retort in the palm of a hand, has been stamped on each one of the transparent bags filled with polyethylene granules. Accept these gifts from the magician chemistry! it seems to be saying. In other of the country's enterprises, these white granules find their way into corrosion-proof pipes, machine-tool parts, sheeting for greenhouses, insulation materials.... [Text] [Moscow NEDELYA in Russian No 47, 19-25 Nov 79 p 2] 8963

NEW COAL-MINING MACHINE--Chelyabinskaya Oblast--The Kopeysk Machine-Building Plant imeni S.M. Kirov has begun production of the new GPK-2 combination cutting and loading machines to be employed in the extraction of coal. The productivity and range of utilization of the new unit are significantly greater than the machines formerly used. The GPK-2 has greater available power; that of the motors driving the cutting and loading systems themselves has been increased twofold. [Text] [Moscow IZVESTIYA in Russian 25 Nov 79 p 2] 8963

PIPELINE COMPRESSOR-STATION CONSTRUCTION--Saratov--Construction has begun near the village of Yekaterinovka on a compressor station on the route of the future Chelyabinsk-Petrovsk-Novopskov gas pipeline. Responsible for the erection of this important facility is a Polish construction crew from Energopole. [Text] [Moscow IZVESTIYA in Russian 20 Nov 79 p 2] 8963

PETROLEUM REFINING FACILITY--Kuybyshev--The first stage of a blended petroleum processing and storage facility has gone into service at the head of the Druzhba oil pipeline. Comprising this great river of oil flowing from Kuybyshev to our western borders are many streams from Siberia, Central Asia and the Povolzh'ye. The fuel at this point is of varying composition: one has more sulfur, another more paraffin and other impurities. The oil has to be brought to the point where it meets certain conditions. It is for this purpose that this facility has been constructed in Kuybyshev. It has a capacity of several hundred thousand cubic meters. The refining processes employed here were first adopted in our country. [Text] [Moscow PRAVDA in Russian 27 Nov 79 p 2] 8963

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